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Contents of this Issue

Page

WITH THE EDITORS....236

SUGGESTIONS FOR PROFITABLE READING....237

PILGRIM STATE HOSPITAL REQUIRES SERVICES OF COMPLETE PLANT....238

PROPELLER TYPE FORCED DRAFT FANS. By W. R. Loveless....244

STEEL CASED BOILER SETTINGS....246

COST OF HIGH-PRESSURE BLOWING....247

STORAGE OF LUBRICANTS. By Allen F. Brewer....248

VACUUM REFRIGERATION OPENS NEW INDUSTRIAL FIELD. By D. K. Dean....250

PIPE LINE TRANSMISSION OF POWDERED MATERIAL. By Fredrich Schulte....252

MODERN WELDED PIPE INSTALLATION....253

DR. W. D. COOLIDGE RECEIVES WASHINGTON AWARD FOR 1932....254

CÖOPERATION BETWEEN PRIVATE PLANTS AND THE UTILITIES—II. By Ottomar H. Henschel....255

INADEQUATE GROUND CONNECTION CAUSES PECULIAR TROUBLE. By V. E. Johnson....258

SAFETY LOCK FOR LINE AND SUBSTATION SWITCHES. By Vernon W. Palen....258

COMMUTATION CONSIDERED AS A SWITCHING PHENOMENON....259

DIESEL ENGINE UPKEEP. By Edward J. Kunze....262

A FAST ONE FOR THE SCIENTIST....264

STEAM FLOW CHART FOR LOW PRESSURES. By Julius Hulman....265

PROSPECT DIVERSION PROJECT WITH 7200-KW. HYDROELECTRIC PLANT....266

RECORD INSTALLATION OF MERCURY-ARC RECTIFIERS....269

OFF DUTY....270

READER'S CONFERENCE: WHAT PRICE NEGLECT? CALIBRATING VACUUM GAGES. PUMP REPAIRS. MOLD IN STORAGE ROOMS. BOMB CALORIMETER DETERMINATIONS. CORLISS GOVERNOR SUPPORTS WERE HAZARDOUS....271

PLANT OPERATION PROBLEMS....274

ADJUSTABLE FLOW METER....275

FEED PRESSURE REGULATING SYSTEM....275

LAMME MEDAL AWARDED TO GIUSEPPE FACCIOLI....275

DEATH OF WILLIAM T. WALKER....275

NEWS FROM THE FIELD....276

FOR THE ENGINEER'S LIBRARY....276

Contents of back issues of Power Plant Engineering will be found in Industrial Arts Index, on file in public libraries.

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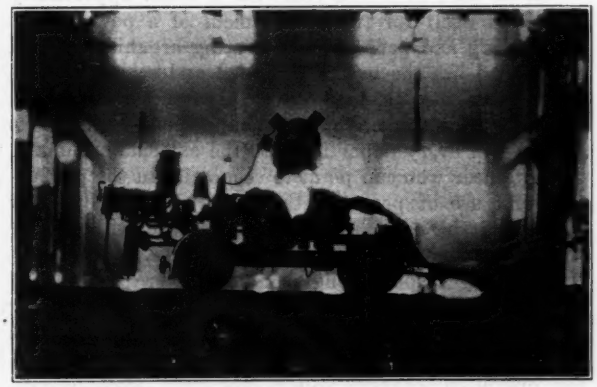


The Reel Backed Snozzle

ALTHOUGH WE appreciate the half-hearted efforts of zoos to keep a few elephants, zebras and giraffes around to acquaint us with exotic nature in far off countries, we feel that these same zoos should be severely censored for their lackadaisical efforts to assist Boob McNutt in landing his ark full of hammer headed ozos, whisk broom ankus, funnel kleas, etc., etc.

Perhaps a few skeptical individuals doubt the existence of such queer animals but these doubts are groundless. Such creatures do exist and our staff big game hunter, at tremendous expense, has just located a new species of snozzle in Ohio. More than that, he obtained a photograph because like all big game hunters he's a terrible liar and we demand that he bring proof.

This queer animal (his name is Oswald) is tougher than the man who chews nails and spits rust. Oswald chews barbed wire (he always carries a reel of special eating wire on his back) and spits molten metal. After many years of patient effort, Lincoln Electric Co., who raised him, have trained him to walk along the top of a large pipe and weld up seams. He is still wild, however, and they keep him chained up by the tail.

Now Oswald is somewhat of a secret and has never been advertised, so he remains comparatively unknown. We won't give the secret away and tell you just where he is located in Ohio. Anyway, there is usually a convention on at Cleveland with the hotels full, so that many of the early visitors without hotel reservations would find it necessary to camp on the curb all night. This is not so comfortable on these chilly winter nights.

After all, comfort is worth a great deal, so much in fact that large power plants are necessary to furnish heat, light and modern conveniences. The State of New York has just finished a group of 40 buildings known as the Pilgrim State Hospital. The power plant which serves this unusually large institution is described on page 238. If you are not duly impressed, it's simply because you've not been a guest of the institution. (Modesty prevents our saying that reading the article is almost as good as a visit.)

WITH THE EDITORS

When Real Worth Is at a Premium

At no time in recent years has a better opportunity presented itself for the management of a power plant to build up and perfect the operating organization and at no time has the need for skilled and scientific engineers been more pronounced than in these days when manufacturers must meet competition with costs trimmed in every department to the extreme minimum. The engineer who can point to economies in the production and use of power is the one who is needed and wanted in the organization—the one who will survive the readjustment that is now taking place.

In many respects, engineers in power plants have fared better than in most fields of industry for, as long as factories are kept in operation, their power plants must be kept in service and the number of men required for operation changes much less than load output. Those in the field who have been less fortunate were engaged in construction and repair work, which has fallen to a minimum during the present retrenchment. Many of those exceptionally competent engineers are now open for employment and from among their number plant executives are selecting men to replace the incompetent, unskilled or otherwise undesirable operators who have been maintained in their organizations.

Competition among engineers for permanent positions is extremely strong and, with the amount of unemployment that is prevalent, the rule of the survival of the fittest is sure to make considerable turnover in the operating personnel of power plants of the country. Fortunate is the engineer who, in these times, has kept himself well informed on the advanced practices of the day, made use of every device and scheme available for reducing costs in his field and earned the favor of his employer by exhibiting technical skill, scientific knowledge and unquestioned loyalty in the work entrusted to him.

The Cost of Indolence

Fortunately for the peace of mind of the world it seldom knows of the wonderful developments that are almost perfected but which for the lack of a few dollars or a little labor sink into oblivion. Many a genius with a strong mind and a weak back has faltered on the brink of success.

For the last few years, advantages of the coal dust engine have been heralded and developments watched with considerable interest in all parts of the world. Yet today the fact that we do not have a coal yard on every corner instead of a gas station rests on a quirk of fate. If a certain potential genius had been a trifle more industrious, the entire course of several industries might have been changed.

At a machinery exhibit some years ago, an old gentleman stepped up to one of the pulverizer booths and wanted to know how fine they could grind material, particularly coal. When told that 500 mesh was common in some industries, he wanted to know if this was fine enough to burn in an automobile engine. He was told that it probably was and was then questioned to find out what he was doing with an engine burning pulverized coal. He said that years ago he had an automobile he used to ride around with. The engine burned pulverized coal as fuel. Naturally he was asked where it was and why he no longer used it. To which he replied: "Quit using it because it was too much work grinding up the coal with a mortar and pestle."

Warehouse Taxes

An interesting tax question came up in Pennsylvania recently in connection with cold storage warehouses. Tax rates on manufacturing plants are somewhat lower than on usual structures and refrigerated warehouses have heretofore not been included in the manufacturing classification but have been subject to the higher tax rate.

Assuming an equitable tax structure, this discrimination is obviously unfair because cold storage warehouses manufacture their weather at considerable expense. There is no question about the status of an ice plant, machinery is installed for the express purpose of making ice. Yet when this same equipment is installed for the purpose of manufacturing weather or climate its classification automatically changes and the tax rate goes up.

If this is a local condition, probably little can be done to remedy the condition because the number of cold storage warehouses is small in any community while tax reform is a difficult matter for a minority to put through. If common in many parts of the country it is a matter for the National Warehouse Association to take up and try to rectify by means of a stiff and united front.

Vacuum Tubes enter Precipitator Field

For nearly 30 yr., the Cottrell electric precipitator has been taking silver, gold, cement, sulphuric acid, arsenic, coal tar products and other valuables out of smoke and flue gases that go up the chimneys of smelters, chemical works and manufacturing plants. The process depends upon the electrostatic attraction of high voltage unidirectional current. It has always involved the troublesome feature of a mechanical 30,000 to 60,000-v. rectifier—a sort of electrical pinwheel, turning at high speed, surrounded with flame, broadcasting uproar to all radio sets for miles around and demanding frequent repair.

Thermionic tubes may soon replace this mechanical rectifier. The idea, tried several years ago, but abandoned because of the extremely short life of the tubes, is now made practical by the development of new and better tubes. Two successful installations have been operating this year, and so far have shown a satisfactory tube life. In some cases the tubes have lasted for more than 3000 hr.

Suggestions for Profitable Reading

Storing Oil in Puddles on the Floor

When you look at the picture on page 248 showing how not to store lubricants, you will recognize at once that it was taken at a plant you know about, over on the other side of town. Jones, the engineer there, is a good fellow, keeps his plant running fairly well and all that but is none too careful about certain details. One of the process superintendents of that plant may have told you in confidence that Jones had a run-in with the general manager not long ago about his high lubrication costs.

You can readily see the reason for them. Compare that picture of how not to do it with the other picture, which bears a good resemblance to your own lubricant storage room. There's the answer right there. It certainly will do no harm, next time you see Jones at the Engineer's Club luncheon, to ask him if he saw that article in Power Plant Engineering about oil storage. Tell him you found a couple of good ideas in it that you could use. Perhaps he'll look it up and start thinking about it. He certainly ought to, although of course you can't come right out and tell him so. But your gentle hint may set him on the road to saving some money. Oh, no! He'll never thank you for it. Nor Power Plant Engineering either. He'll believe he thought of it all himself. But the net results will be good and that's all we care about.

Wind Instruments of the Power Plant Orchestra

To the conductor of that mysterious symphony of the power plant whose every note must harmonize according to a well-conceived and carefully-executed plan, all woven about the single theme, "Power and steam at the lowest cost consistent with reliability and flexibility", no instruments in his great orchestra are more important than the wind instruments—the equipment for producing draft in the boiler furnaces or for producing air at high pressure for manufacturing and process work. Even in the smallest boiler installations, the forced draft fan permits operation over a wide range of boiler capacity, enables the boiler and furnace to be designed for more efficient combustion conditions and transforms the entire boiler operation into a scientific chemical reaction that can be satisfactorily controlled to meet varying needs. Elsewhere in this issue, Mr. Loveless discusses some of the interesting features of forced draft fans, while Mr. Pearce presents data on the costs of high-pressure blowing.

And Now for a Little Diversion in the Form of Black Magic

Oh, yes, it's a real diversion. For on page 266 of this issue is a detailed description of one of the most interesting water diversion projects that have been carried out in this country. In connection with the Prospect No. 2 hydroelectric development of the California-Oregon Power Co. on the Rogue River in Oregon, a new system of dams, canals and flumes has been built to divert water from several branches of the river and make it usable at Prospect No. 2. As a matter of fact, 350 sec-ft. additional flow has been made available at Prospect No. 2 and in the process of collecting it, 7200 kw. of power can be developed at a new completely automatic power house, Prospect No. 3.

To place this power house in operation, when there is water enough and with all the protective devices and equipment in proper condition for starting, the operator at Prospect No. 2 merely closes the main oil circuit breaker in the transmission line connecting the two plants. Then, in Prospect No. 3 power house, contactors click, relays spin, valves operate, water swishes to the hydraulic turbine, auxiliary motors start, soon the machine is nearly at full speed, the main generator breaker goes "thunk" as it automatically closes and connects the unit to the line and the needles of the wattmeters and ammeters begin to swing up their scales as the machine supplies power to the system. And all this without the touch of a human hand! If that isn't black magic, then Houdini was no magician.

Engineering Problems of a Hospital for 6600 Patients

When the Power Plant Engineering editor stepped from the train at Brentwood, Long Island, one bright morning, and inquired his way to the Pilgrim Hospital, he was astonished when he finally found himself being conducted through a great group of well-designed brick buildings set in a rolling landscape and reaching into the distance as far as the eye could see. Was this all one hospital? It seemed more like a small city.

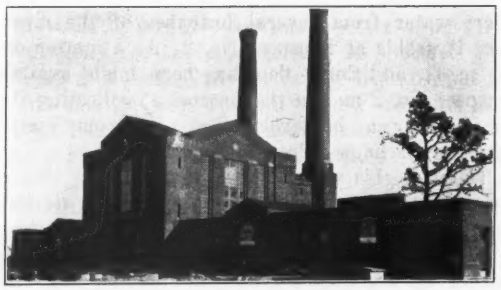
That, in effect, it is, a small city of forty-two separate buildings, occupying about 1000 acres of ground, nearly 2 sq. mi. and designed to care for 6600 mentally-deranged patients. Certainly the engineering problems of such a community should be of interest to every engineer. On page 238 of this issue you will find the details of the engineering equipment and its operation.

The hospital has its own power plant, entirely independent of outside supply, from which a well-designed tunnel system carries steam piping, power conduits and other services to the various buildings. The institution has its own water supply and sewage system, its own fire department and operates as a completely self-contained economic unit. It is one of the newest of the hospitals for the insane maintained by the State of New York, which has established fifteen of them in various parts of the state.

UNDER PRESENT accepted standard, excellent lighting for industrial plants would be 20 to 30 foot-candles. Curiously enough, this sounds excessive, and looks very bright when installed. But under the open sky, unless the daylight measures one hundred foot-candles or more, one gets the impression of a very dull day indeed.

Pilgrim State Hospital

Requires Services of Complete Plant



From a Single Central Plant the Institution Gets all its Power, Heat, Refrigeration and Water Requirements

SERVING AN ENTIRE city with light, heat, refrigeration, hot and cold water, sewage disposal, fire protection and all the convenience of electricity and steam from one power plant seems like a big order, and it is. Nevertheless the new plant at the Pilgrim State Hospital, Brentwood, Long Island, N. Y., does just that.

Three years ago the site of this institution was a waste area of pine brush. Since that time over 1000 acres have been cleared and 44 large modern hospital and service buildings have been and are being constructed in which to care for 6600 insane patients who have become charges of the State of New York. This entire work has been carried out by the State through the Department of Public Works, Division of Architecture, and represents an expenditure of several millions of dollars. Several other state institutions* of a similar character have been so successfully served by central power and heating plants that in this instance the same plan was followed out with the plant located near the south boundary of the institution grounds which is about two miles from the farthest building it serves.

Railway service is available through the Long Island Railway with a siding running to the plant on a trestle from which coal is delivered to the conveying system. The water used throughout the institution is pumped by remote controlled motor driven pumps from eight wells, 170 ft. deep, carefully located through the grounds, the farthest being 2 mi. from the plant. The pumps deliver to a completely covered reservoir of 1,500,000-gal. capacity and from there it is pumped to a 400,000-gal. stand pipe 110 ft. high.

Sewage from all the buildings drains to a sump from which it is taken in an 18-in. main to the sewage plant where it passes successively through two Imhoff tanks, a weir tank, two dosing tanks and on to the seepage beds covering 18 acres. The sewage is handled by four American centrifugal pumps, two 6-in. and two 10-in., driven by Burke motors.

From the plant, tunnels radiate to all the buildings

*See Power and Heating Plant of Utica State Hospital, Power Plant Engineering, May 1, 1922, and Making Steam for a Large Institution (Central Islip) Nov. 1, 1922, Issue.

FIG. 1. ENGINE GENERATOR UNITS SUPPLY POWER AND EXHAUST STEAM FOR THE INSTITUTION

FIG. 2. OIL SEPARATORS AND STEAM PIPING OVER PUMP PIT

FIG. 3. THREE OF THESE ENGINE DRIVEN BLOWERS SUPPLY THE FORCED DRAFT

FIG. 4. BOILER FEED AND HOT WATER SERVICE PUMPS ARE ON THE BASEMENT FLOOR UNDER THE HEATERS

and accommodate the water and steam piping and electric cables so that no overhead lines or piping are used. Refrigerating piping goes to the cold storage rooms in an adjacent store building. Individual refrigerating plants are provided for various kitchens.

As an initial installation, three engine generating units are installed with a total capacity of 3781 kv-a. and space is provided for another unit of 1500 kv-a. Four 1004-hp. boilers are now installed with provisions for two more of the same size when the load demands the additional capacity. So far as possible, exhaust steam will be used for heating purposes but a great share of the time live steam will be required for house and water heating. Refrigeration is furnished by two 50-t. and one 30-t. compressors located at one end of the power house building.

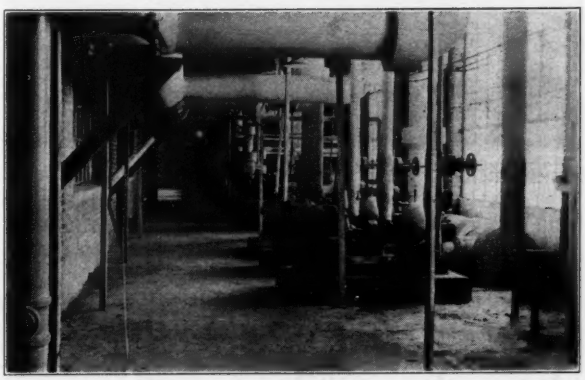
Features of Boiler Room Equipment

As indicated on the plans, the four boilers installed are designated as Nos. 1, 3, 4 and 6, with space left for Nos. 2 and 5. These boilers are Union Iron Works water-tube type generating saturated steam at 150 lb. pressure, erected in a steel encased setting.

Each boiler is rated at 1004 hp., having a heating surface of 10,040 sq. ft. The projected grate area serving the boiler is 164 sq. ft., giving a ratio of heating surface to grate area of 61 to 1. The furnace volume is 4400 cu. ft., giving a ratio to the heating surface of 0.438 to 1 and a ratio of furnace volume to projected grate area of 26.8 to 1.

In the construction of the boiler 750 3¼-in. No. 10 gage tubes were used, the design being for 200-lb. working pressure. These are 4-drum boilers, two steam drums of 42 in. diameter with 29/32-in. shells, a 36-in. steam drum with 25/32-in. shell and the lower drum 48 in. diameter with 1 1/32-in. shell, all joints being double riveted. The boilers are baffled for three pass gas travel with 12 by 12 by 2-in. tile.

Serving these boilers are Taylor type M underfeed stokers, each being seven retorts in width and 33 tuyeres long. They are driven by individual Troy engines under the control of Hagan combustion control system. The stoker drive itself is the straight line mechanism em-



ployed on standard Taylor stokers so arranged that the thrust on the main feed coal ram is in a horizontal direction without angularity which would tend to wear the rams and ram boxes. The stokers are equipped with steam ash dumps.

For observing the operation of the boilers, a separate instrument board is provided for each where Ellison 3-point draft gages, Bailey steam flow meters and Ashcroft pressure gages are mounted. Tubes are dusted by means of Vulcan soot blowers and feedwater is controlled by S-C Swartwout regulators, two of which are mounted on each boiler. The feedwater piping consists

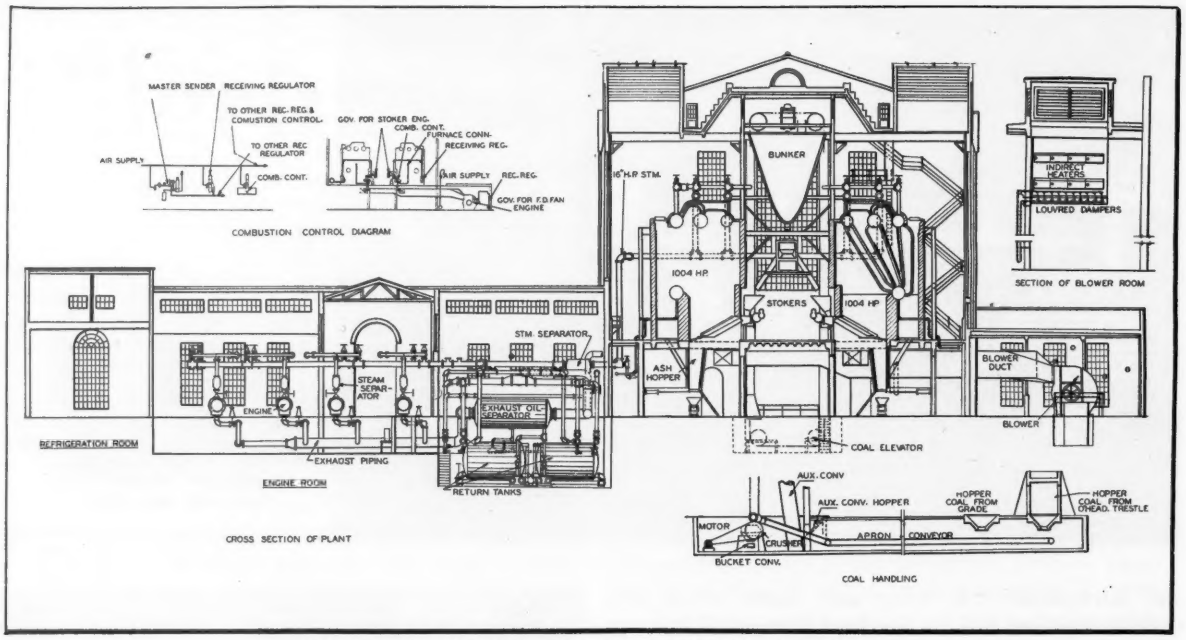


FIG. 5. GENERAL AND DETAIL CROSS SECTIONS OF PLANT

of two hot and one cold water lines valved in such a way as to insure continuous feed even in case of unusual piping failures.

Combustion Control System

One of the most interesting features of the plant is the compensated draft combustion control system. Remote operating regulators are employed to minimize the use of line shafting and to provide, if desired, individual control over each boiler. The system consists essentially of the control of the uptake dampers simultaneously on all boilers in accordance with fluctuations in steam demand, and the individual adjustment of each undergrate damper to supply the necessary air for com-

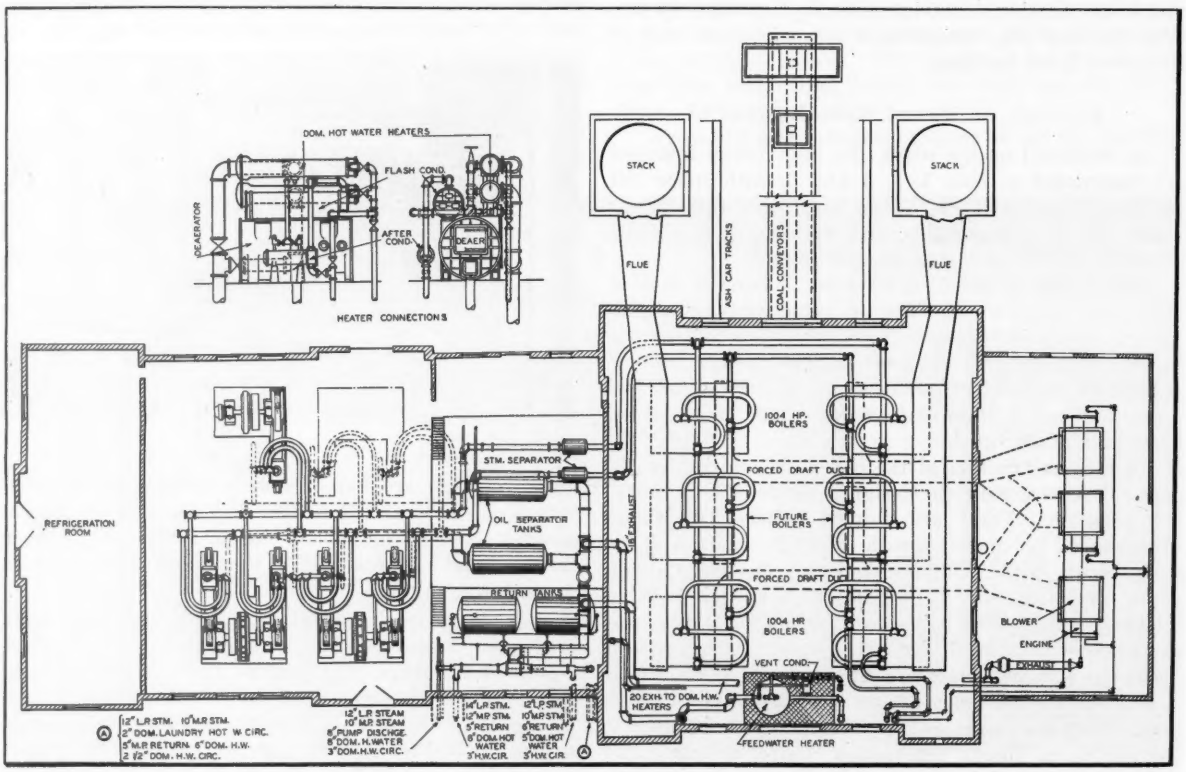

DOM. HOT WATER HEATERS
FLASH COND.
DEAERATOR
AFTER COND.
DEAER.
HEATER CONNECTIONS
STACK
STACK
FLUE
FLUE
ASH CAR TRACKS
COAL CONVEYORS
1004 HP. BOILERS
FORCED DRAFT DUCT
FUTURE BOILERS
FORCED DRAFT DUCT
1004 HP. BOILERS
VENT COND.
STM. SEPARATOR
OIL SEPARATOR TANKS
RETURN TANKS
REFRIGERATION ROOM
EXHAUST
BLOWER
ENGINE
EXHAUST
20 EXH. TO DOM. H.W. HEATERS
FEEDWATER HEATER
12" L.P. STM. 10" M.P. STM. 2" DOM. LAUNDRY HOT W. CIRC. 5" M.P. RETURN 6" DOM. H.W. 2 1/2" DOM. H.W. CIRC.
12" L.P. STEAM 10" M.P. STEAM 8" PUMP DISCHGE. 8" DOM. H. WATER 3" DOM. H.W. CIRC.
14" L.P. STM. 12" M.P. STM. 5" RETURN 8" DOM. HOT WATER 3" H.W. CIR.
12" L.P. STM. 10" M.P. STM. 6" RETURN 5" DOM. HOT WATER 3" H.W. CIR.

FIG. 6. GENERAL LAYOUT OF PLANT AND HEAT CONNECTIONS

bustion to each boiler regardless of variations in the resistance of the respective fuel beds. This insures equal distribution of load among boilers on the line, thus permitting all units to be operated at their most efficient ratings.

Responding to variations in steam demand and pressure in the main header, the master sending controller transmits a variable pneumatic pressure or impulse to each of the four receiving regulators connected to the boiler outlet dampers, and to the fifth receiving regulator controlling the speed of the three forced draft fans in the basement. A ⅜-in. standard pipe carries the transmitting pressure between the master sending controller and the receiving regulators. The transmitting air pressure varies between 10 and 50 lb. per sq. in., depending on the demand for steam and in this way provides adjustment of the regulator governing damper opening and fan speed requirements. There is practically no flow through this transmitting line, so that these adjustments are duplicates of the master controller movements.

Boiler receiving regulators are mounted so as to secure easy mechanical connection to the individual outlet dampers. Connections are also made from these receiving regulators to the respective stoker engine governors, thus providing the means for fuel regulation. The forced draft fan speed regulation is obtained by individual governor adjustments, which are secured through suitable connections to a short jack shaft directly connected to the fifth receiving regulator mentioned above.

Control of the undergrate wind box dampers is from furnace suction. An individual controller on each boiler provides this regulation through a direct connection to the damper shaft.

All regulators are completely adjustable. They are also provided with means by which the operator may open or close dampers for soot blowing, or inspection, whether the boilers are on the line or not.

Forced draft is furnished by three No. 15 Sirocco fans driven by Ridgway engines. These have special governors that respond to the boiler load demand through the combustion control system. Air for combustion is drawn into the blower room through louvers under the roof and heating coils are provided to increase the atmospheric air temperature. As exhaust steam is used for this purpose the heat balance is aided by this scheme. Two ducts convey the air to the boiler room basement where the branches are so arranged that each duct will feed three boilers. A crossover in the blower room permits the use of any combination of blowers and boilers desired.

Coal Handling Is Entirely Mechanical

Coming to the plant in railway cars on the Long Island R. R. tracks, or, in emergency, by truck delivery, coal is delivered to track hoppers, two of which are provided, one a trestle hopper and the other at grade level. Both of these discharge through rack-and-pinion gates to a 30-in. apron conveyor, 91 ft. long which delivers the coal to a 24 by 24-in. single roll crusher.

After crushing, the coal is carried for 88 ft. vertically by the Perkins cantilever type pivoted bucket carrier and discharged to a 93-ft. flight conveyor, the trough of which is fitted with ten rack and pinion gates, making it possible to distribute the coal evenly in the storage bunker. From the bunker the coal is drawn through any one of eight duplex gates and loaded into the 2000-lb. motor driven weigh larry from which it is fed to the stoker.

In addition to the above standard equipment, there is also an auxiliary continuous bucket elevator—42-ft. centers—which may be loaded from an emergency truck hopper and which will discharge coal at the rate of 25 t. per hour directly to the weigh larry.

The entire coal handling system is the product of the Webster and Weller Mfg. Co. and was designed to handle 60 t. per hour. Special Cutler-Hammer push button control is employed throughout the entire system.

FIG. 7. FLIGHT CONVEYOR OVER BUNKER IN BOILER ROOM

FIG. 8. PIVOTED BUCKET HEAD SHAFT EQUIPMENT

Water Heating for Boiler Feed and Service

Feedwater for the boilers is secured from wells and comes to the plant through the water supply system of the institution. The character of the water is such that it is not given chemical treatment but goes from the service mains to a 240,000 lb. per hr. Cochrane deaerating metering heater which is of somewhat special construction in that the V-notch weir is located in the deaerating heater proper mounted on top of the storage tank. This permits of utilizing the entire volume of the storage tank for storage purposes. Valve controlled bypasses provide for the continued operation of the heater, even though the meter or storage tank is cut out of service for any reason.

Domestic water heating is accomplished by a 50,000 gal. per hr. Cochrane deaerating hot water generator, of solid cast-iron ring construction, in conjunction with

which two preheaters are employed. Each of these has a capacity of 417,000 lb. per hr. The main heater is of the evaporator type in which the steam used in heating and deaerating the water does not come into actual, or direct, contact therewith. Instead there is immersed in the storage space of the heater a tube bank which receives steam from the same supply to which the two preheaters are connected.

This submerged surface, or evaporator as it is called, generates steam which, rising from the surface of the

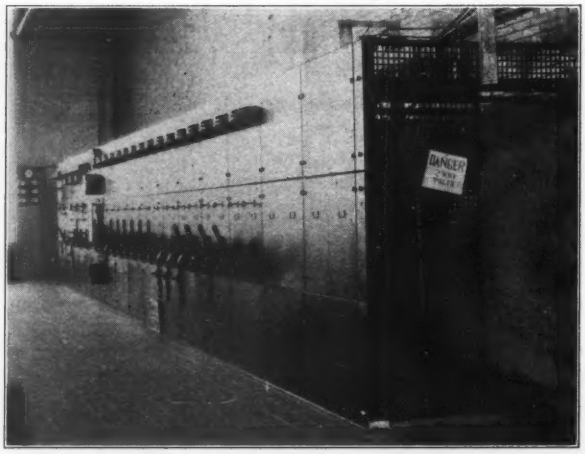


FIG. 9. ENGINE ROOM SWITCHBOARD

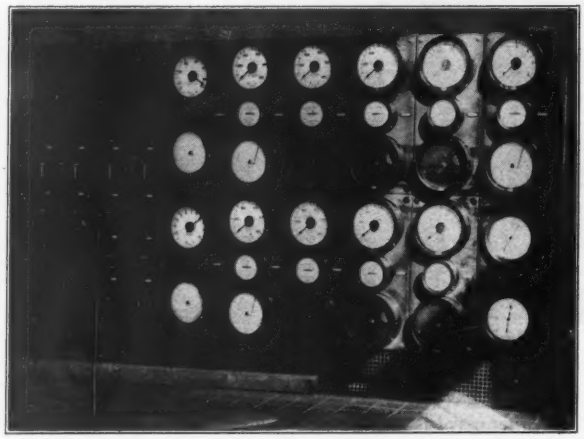


FIG. 10. THE WATER SYSTEM IS CONTROLLED FROM THIS GAGE BOARD

water, completes the heating of the water falling over trays and, with the liberated gases, is drawn out through a vent condenser by means of an air pump. By placing part of the heating surface in an external preheater, the total amount of surface required is greatly reduced, as the average temperature difference in the preheater is greater than it would be if all the surface were included in the evaporator element, besides which the water circulation through the preheater is rapid, which is conducive to a higher coefficient of heat transmission. Deaeration frees the hot water of oxygen and is recognized as an effective method of preventing pipe corrosion.

For the laundry service a six-pass, floating head, closed heater containing 12-ft. tubes and having a capacity of 83,000 lb. per hr. heats water from 50 to 200 deg.

Generation of Electric Energy

All electric power used about the institution is generated at the plant, three Ridgway engine generating sets being provided for this purpose with space allowed in the engine room for a fourth unit. One of these units consists of a single 1070-hp. engine with 703-kw. 3-phase generator and 15-kw. direct connected exciter. The other units employ twin engines, each element having a rating of 1070 hp. or a combined capacity of 2140 hp. used to drive a 1350-kw. a.c. generator and a belt driven exciter of 25-kw. capacity.

These engines are of the non-releasing four-valve type having a governing mechanism on the twin engines of especial interest. This consists of a single flyball governor, two gear cases connected by means of a cross-shaft and two layshafts. Spiral gears and layshafts (one on each side of the unit) furnish the driving power to the gear cases wherein are contained the variable cutoff mechanism for operating the admission valves, together with a constant speed shaft for driving the exhaust valves. The cross-shaft used here merely serves as a part of the governing mechanism, controlling the position of the cutoff links. The flyball governor is employed to move only a small balanced pilot valve on a servo-motor which makes its action extremely sensitive.

Oil at 100 lb. pressure supplies the motive power to the servo-motor for shifting the valve gear links which control the cutoff to suit the load on the generator. A small motor is used to change the speed of the engines when paralleling two units. The motor merely has to raise or lower the pivot point of the main control lever and does not in any way affect the regulation of the governor.

Use of Exhaust Steam

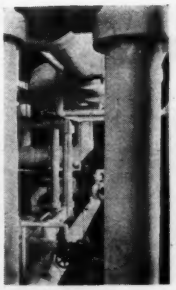
All exhaust steam from the main engine units and steam driven auxiliaries is used in the vacuum heating system serving the institution. Two large oil separators are provided to purify the exhaust steam on its way from the engines to the heating mains, these being located in the pump well at one end of the engine room.

Condensate from the heating system returns through the tunnels and is picked up at the plant entrance and pumped to the feedwater heater, two 10 by 14 by 12-in. Worthington pumps being provided for this purpose. The vacuum is maintained by Nash vacuum heating pumps driven by General Electric motors.

Refrigeration needs of the institution are supplied from the plant by two 50-t. and one 30-t. York Ice Machinery Corp. ammonia compressors which are driven by synchronous motors supplied by the Electric Machinery Mfg. Co. All this refrigerating machinery is located in the east end of the plant, the cold brine being circulated through piping in tunnels to the various buildings where it is used principally for food preservation.

Dr. Frederick W. Parsons is the Commissioner at the Head of the State of New York Department of Mental Hygiene and supervises the state hospitals under this department through superintendents who have their offices at the various institutions. At Pilgrim State Hospital Dr. William J. Tiffany is superintendent of the institution and Soren P. Anderson is chief engineer in charge of the entire mechanical and electrical equipment. Acknowledgment is due these officials for courtesies extended and assistance in the preparation of this descriptive article.

Principal Equipment Installed in the Power Plant of the Pilgrim State Hospital



PILGRIM STATE HOSPITAL, located at Brentwood, Long Island, N. Y., institution for the insane; plant serves all buildings of this institution located over an area of 1000 acres, with electric lights, power, heating, refrigeration, water from wells and disposal of sewage. Load is steady. Plant construction was started in 1930; started operation September, 1931; designed by the Division of Architecture, Department of Public Works, State of New York. Walter H. Taverner Corp., engineering contractor in charge of installation.

STEAM GENERATION

BOILERS—4, Union Iron Works, 1004 hp., 150 lb. pressure, saturated steam, 10,040 sq. ft. heating surface, 4400 cu. ft. furnace vol., 750—3¼ in. tubes, 4 drums, steel encased.

SOOT BLOWERS—Vulcan Soot Cleaner Co.

STOKERS — 4, American Engineering Co. Taylor underfeed with steam ash dump, engine drive for individual stokers, 7 retorts, 33 tuyeres long, 164 sq. ft. projected area.

ENGINES—4, Troy Engine & Machine Co. Stoker drives 5 by 4 in. Gardner governor and Hagan control.

CHIMNEYS—Sapero, 2, brick, 200 ft. high.

FEEDWATER HEATER — Cochrane Corp., 1—8000 hp. metering deaerating.

COAL AND ASH HANDLING

COAL HANDLING—Webster & Weller Mfg. Companies, 2 track hoppers, Webster apron conveyor 30 in., 91 ft. long. Perkins Cantilever bucket carrier, 93 ft. flight conveyor; 2000 lb. weigh larry; auxiliary Webster continuous bucket elevator 42 ft. centers; Fairbanks scales.

CRUSHER AND APRON CONVEYOR DRIVE—1, 25-hp. 3-phase, 60-cycle, 220-v. Burke enclosed slip ring motor at 1200 r.p.m., with special Cutler-Hammer automatic starter with 3 extra push button starters.

PIVOTED BUCKET CARRIER DRIVE —1, 10-hp., 3-phase, 60-cycle, 220-v. Burke enclosed slip ring motor at 900 r.p.m., with 1 Cutler-Hammer automatic starter including 3 extra stop stations.

FLIGHT CONVEYOR DRIVE—1, 10-hp., 3-phase, 60-cycle, 200-v. Burke standard squirrel cage enclosed motor at 1200 r.p.m. with 1 special Cutler-Hammer automatic compensator including 3 extra stop stations.

WEIGH LARRY DRIVE—1, 3-hp., 3-phase, 60-cycle, 220-v. Burke enclosed slip ring motor at 1200 r.p.m., with 1 Cutler-Hammer reversing drum controller with reversing starting resistor and primary contactor.

AUXILIARY ELEVATOR DRIVE—1, 5-hp., 3-phase, 60-cycle, 200-v. Burke enclosed slip ring motor at 1200 r.p.m., with 1 Cutler-Hammer enclosed 3-p.s.t. unfused 30-amp. size safety switches and 1 relay panel including 6 magnetic relays mounted in wall type enclosing case for proper interlocking of conveyor motors.

ASH GATES—Allen-Sherman-Hoff Co., 3 per boiler, hydraulic operated.

ASH TRUCKS—Easton Car & Construction Co.

PUMPS

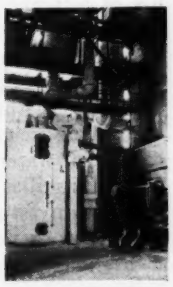
BOILER FEED PUMPS—Frederick Iron & Steel Co., 2 stage centrifugal; 4 in. 520 g.p.m., 3000 r.p.m., driven by Murray turbines, 104 hp., 100 to 150 lb. steam pressure, 10 lb. back pressure; Fisher governors; Ashcroft pressure gages.

WATER SERVICE PUMPS—Frederick Iron & Steel Co., 3 centrifugal, 450 g.p.m., 17.7 ft. head, 1740 r.p.m., Westinghouse motor drive, 220-v., 3-phase, 60-cycle, 40-hp. Sundh Electric Co. pressure control system.

OIL PUMPS—1 Worthington direct acting duplex, 6 by 5¾ by 6 in. with Mason regulators and 1 Worthington single stage, General Electric motor drive, 7½-hp.

FIRE PUMPS—1 American Pump Co., 1500 g.p.m., centrifugal 200 ft. head, 1750 r.p.m. driven by 1 25-hp. Burke induction motor, 2200-v., 3-phase, 60-cycle.

HEATING SYSTEM PUMPS—Nash Engineering Co. throughout system and 2 Worthington Pump & Mach. Corp. 10 by 14 by 12 in. return to heater.



ELECTRIC GENERATING UNITS

ENGINE GENERATOR UNITS—1—781 kv.a., 2—1500 kv.a. Elliott Co.

ENGINES—1 Ridgway 4-valve, 29x36 in. each 133 r.p.m., 150 lb. pressure to zero back pressure and 2 Ridgway double 4 valve engines, each 29 by 36 in., 133 r.p.m., 150 lb. steam pressure to zero back pressure.

GENERATORS—1 Elliott Co., 781 kv.a. and 2—1500 kv.a. 90% power factor 703 kw., 133 r.p.m., 2400-v., 60-cycle, 3-phase.

EXCITERS—1 direct connected Elliott Co., 15-kw. and 2 belted 25-kw. 700 r.p.m., 125-v.

MISCELLANEOUS EQUIPMENT

PIPE COVERING—Keasbey & Mattison Co.—85% Magnesia for steam and hot water Novoid corkboard insulation, supplied by Cork Import Corp., New York, for refrigeration piping.

PIPES, VALVES & FITTINGS

VALVES—Ohio Injector Co.
Jenkins Bros.
Consolidated Ashcroft-Hancock Co., Inc.
Crane Co.
Crosby Steam Gauge & Valve Co.—safety valves.
Foster Engineering Co.
Fairbanks Co.
Yarnall-Waring Co.

FITTINGS—Walworth Co.
Stockham Pipe & Fittings Co.
E. M. Dart Mfg. Co.

SEPARATORS—Cochrane Corp.

TRAPS—Cochrane Corp.
Swartwout Co.
Kieley & Mueller.

MISCELLANEOUS INSTRUMENTS

V-NOTCH METER—Cochrane Corp.

WATER METER — Lambert, Neptune water meter.

STEAM FLOW METERS—Bailey Meter Co.

STEAM PRESSURE GAGES, ALTITUDE AND COMBINATION PRESSURE AND VACUUM GAGES — Consolidated Ashcroft-Hancock Co.

WATER FLOW METERS — Republic Flow Meters Co.

COMBUSTION CONTROL—Hagan Corporation.

CO_2 METER—Hays Corporation.

DRAFT GAGES — Ellison Draft Gage Co.

STOKER ENGINE GOVERNOR—Gardner-Denver Co.

FEEDWATER REGULATORS — S. C. Swartwout Co.

HOT WATER TEMPERATURE CONTROL—Fulton Sylphon Co.

BOILER GAGE GLASSES — Paul B. Huyette Co.

REGULATORS FOR PUMP CONTROL —Mason Regulator Co.

PUMP GOVERNORS—Fisher Governor Co.

OIL FILTER, central oil circulating system—S. F. Bowser & Co., Inc.

SWITCHBOARDS

MAIN SWITCHBOARD — Elliott Co. with General Electric Co. instruments and Condit circuit breakers.

PUMP CONTROL BOARD — Electric Controller & Mfg. Co., 2-panel with Republic flow meter, Ashcroft altitude combination pressure and vacuum gage.

TRANSFORMERS — Moloney Electric Co.

ELECTRIC SWITCHES—
General Electric Co. magnetic switches.
Electric Controller & Mfg. Co.
Condit Electric Co. starters and circuit breakers.
Cutler-Hammer Mfg. Co. control systems.
Trumbull Electric Mfg. Co. switches.
Square D Co. switches.
Metropolitan Device Corp.
Murray switch and meter equipment.
Sundh Electric Co. pressure control.

FORCED DRAFT EQUIPMENT

FANS—American Blower Co., 3 No. 15 Siroco with Dodge Timken roller bearings, driven by Ridgway engines made by Elliott Co., each 146-hp., 12 by 16 in. 150 lb. steam pressure to 10 lb. back pressure; 280 r.p.m., equipped with Detroit lubricators and Hagan control.

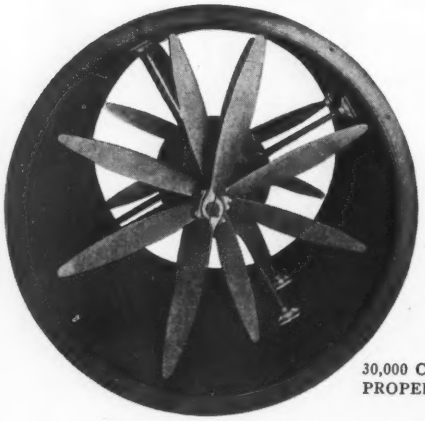
AMMONIA COMPRESSORS—York Ice Machinery Corp., 2—60-ton. and 1—30-t., driven by Electric Machinery Mfg. Co. synchronous motors, 2—125-hp., 1—75-hp., 220-v., 257 r.p.m. and 240 r.p.m.

SERVICE WATER HEATER—Cochrane Corp. 1—50,000 gal. per hr. deaerating hot water generator with 2 preheaters of 417,000 lb. per hr. each, and a vent condenser. 1—83,000 lb. per hr. six pass floating head, 12 ft. tube closed heater for laundry service heating water from 50 to 200 deg.

AIR COMPRESSORS — 1 Curtis Pneumatic Machinery Co. 3⅜ by 3½ in. for combustion control system. Driven by Century Electric Co., 2-hp. motor, 1710 r.p.m., 220-v., 3-phase, 60-cycle, and 1 Westinghouse Air Brake Co., size 10½-150.

POWER PLANT ENGINEERING March 15 1932

Propeller Type Forced Draft Fans



30,000 C.F.M. PROPELLER FAN

Aeroplane propeller fans replace conventional design and save 40 per cent of first cost, 25 per cent in power, and require but a fraction of the space. In service two years in Western Electric Co. plant, handling dust-laden air.

By W. R. LOVELESS
Mech. Eng. Hawthorne Works
Western Electric Co.,
Chicago, Ill.

IN DESIGNING the arrangement of boiler room equipment, one of the problems requiring more than average amount of consideration is the location of forced draft fans and ducts. This is especially true when the design requires the rearrangement of an existing, natural draft boiler house. In 1927 the Western Electric Co. commenced the rehabilitation of its main power plant at the Hawthorne Works. Part of this work required replacement of 12 boilers using natural draft stokers, with new boilers equipped with forced draft chain grate stokers to permit operation at higher ratings. The boiler house contained 16 boilers in battery settings, having a total rating of 8616 hp., located in two rows of 8 boilers each, with the boiler front facing the building centerline. It was necessary that the new boilers be installed to occupy approximately the same floor space as the old boilers and be designed to require a minimum of alterations to the boiler house building.

With this objective, the only feasible location for the forced draft fans was found to be in the basement between the rows of boilers, which, however, was a desirable location from the standpoint of air supply. Pipe services and low voltage electric distributing cables are conducted through a system of tunnels totaling 5500 ft. in length and branching out from both ends of the power plant basement. Forced draft fans in the basement would draw their air supply largely through these service tunnels, thus improving the ventilation therein.

No space being available for a general system of supply ducts to several boilers, it was necessary to use one forced draft fan per boiler. The first four boilers were installed using conventional multi-vane fans of 30,000 c.f.m. of air each at a static pressure of 2½ in. of water, each mounted with the driving motor on a common bed plate and discharging horizontally just below the ceiling into the stoker air ducts, as shown in Fig. 1. The fans were supported by a steel structure and the necessary design was such that the headroom beneath the structure was restricted to 6 ft. This restriction caused considerable inconvenience in working the ash pits, which are of the inclined bottom type, discharging by gravity through gates into a conveyor, but requiring some hand raking.

After installation of the multi-vane fan units and during the preparation of drawings for the second section of four boilers, the writer became interested in the use of airplane propeller type fans for a water cooling tower then being designed and learned that it was feasible to combine airplane propellers in tandem to build up static pressure sufficient for forced draft work. One manufacturer stated that such an installation had been made in marine practice to give a static pressure of 4 in. of water, but that he was not then aware of any similar installation in existence in boiler rooms on land. Further investigation indicated that the installation of such fans would be very economical in space requirements and method of support.

Propellers Tested

Therefore, it was decided to postpone the purchase and further design of the multi-vane equipment and purchase two airplane propeller fans for trial. Two of the mutli-vane fans were removed from two boilers about to be put into service initially and the propeller fans installed in their place. These two propeller fans were of somewhat different design. One had the propellers mounted upon a shaft revolving within a barrel type casing and driven by a motor mounted separately outside of the casing. The propellers of the other fan were mounted upon extensions of the motor shaft at each end of the motor and the motor mounted within the barrel casing, thus making the fan blades, casing and motor, a unit complete in itself as shown in the headpiece.

Installation of these fans was comparatively simple, the barrels being suspended by hangers from the steel structure of the firing floor above and braced at the sides to insure stability as indicated by Fig. 3. The external motor drive of one fan required a suspended platform but this did not reduce the available headroom of 10 ft. below the fan barrel.

Due to the restricted construction of discharge ducts, it was found impracticable to measure accurately the volumes of air delivered by the fans. During tests conducted upon the boilers, however, measurements were taken of the power input to the motors and air pres-

sures and an approximate comparison of the air delivered was possible between the multi-vane fans and the two types of propeller fans by calculations based upon the amount of coal fired and the coal and flue gas analyses. This is a crude method and no single test could be considered within the acceptable range of accuracy, yet since this method would apply to all tests alike, the results would be relative and therefore could guide the engineers' judgment regarding future installations. These tests indicated a considerably smaller power consumption by the propeller type fans than by the multi-vane fans for equal conditions of air discharge.

Advantages

These fans were operated several months before it was necessary to decide upon the type to be obtained for the second four boilers, and a comparison made during this period indicated advantages in favor of the propeller fans over the multi-vane fans, which may be summarized somewhat as follows:

1. First cost of motor and fan considerably less.
2. Installation cost approximately 40 per cent less.
3. Power consumption approximately 25 per cent less.
4. Permits four feet more headroom beneath fan.
5. Permits six feet more room adjacent to centerline of building for locating piping and for electric conduit.
6. Regulating dampers can be placed on suction side of fan with less complication of design.
7. Weight of propeller fan, motor and casing is approximately 20 per cent of the weight of multi-vane fan, motor and bed plate.

The propeller fans made considerably more noise than the multi-vane fans but this was noticeable only in the basement, as the concrete floor above the fans effectively deadened the sound. As a result of this trial installation, six more propeller fans were obtained to serve the other new boilers which were installed.

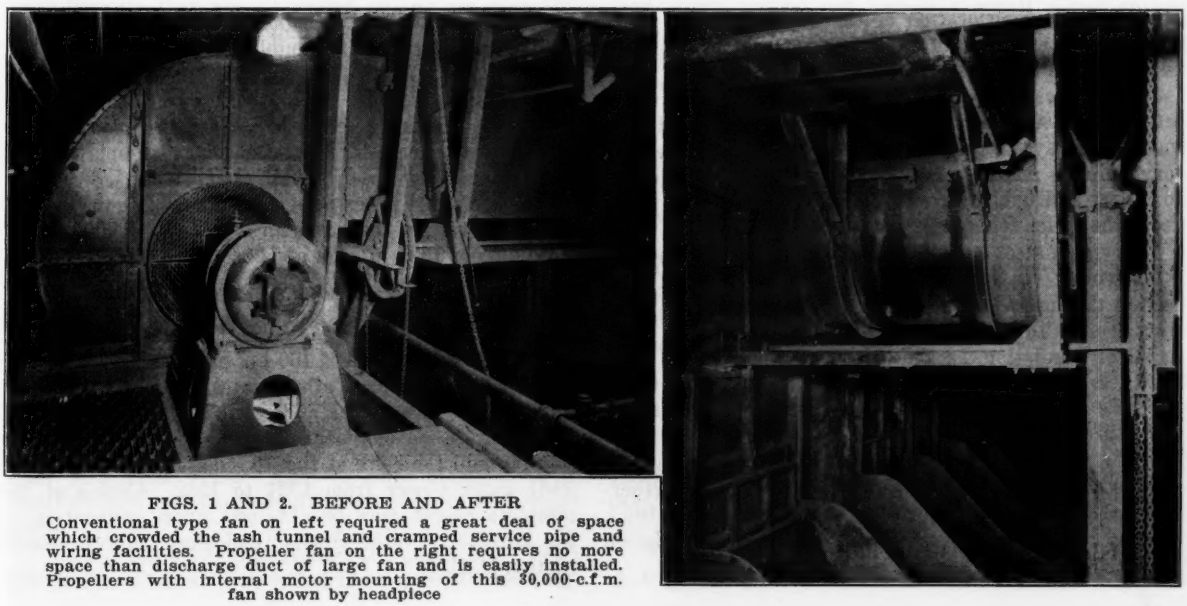
Details of Propeller Fans

Casings of these fans are 42 in. in diameter by 56 in. long and made of steel plate 3/16 in. thick, reinforced by 2 by 2 by ¼-in. angle rings at each end. The motors are of the totally enclosed squirrel cage induction type, rated at 15 hp., 1720 r.p.m., having 1⅝ in. diameter shaft extended 16 in. at each end. On each shaft extension are mounted four 41-in. diameter cast aluminum propellers. Each motor is supported within the casing by eight pieces of pipe attached by flanges at their outer ends to the casing and connected at their inner ends to two yokes encircling the motor. Conduit for electric connections and pipes for oiling the motor bearings are brought through the fan casing for convenience in servicing.

These fans have been in use from one to two years and have had no interruptions in service and no maintenance other than periodical oiling and inspection. As the fan suction is directly above the ash and coal conveyor, it is obvious that the air handled carries considerable abrasive dirt but no detrimental effect has been observed from this condition. Periodical inspections have shown the motors to be clean and the fan blades to be free from perceptible abrasion.

Tests made after the installation of the first two propeller fans indicated that the negative pressure at the suction end of the fan casing was relatively high. This feature was used to good advantage by constructing a small duct from the fan casing to the space between the stoker chain and its front casing. This location is normally under a slight air pressure, caused by leakage from the pressure compartments of the stoker, and air leakage therefrom carries an appreciable quantity of fine coal and ash into the boiler room. The connection to the fan suction creates a sufficient negative pressure to draw cold air into this space and through the stoker chain, thus aiding in keeping the firing floor clean and also cooling the chain. The heat absorbed by this relatively small amount of air is not sufficient to affect the fan motor appreciably.

The installation is generally satisfactory and has demonstrated that this type of fan can be designed and used successfully for air pressures and capacities ordinarily required for forced draft stokers, thereby effecting worth while economies of design and operation.



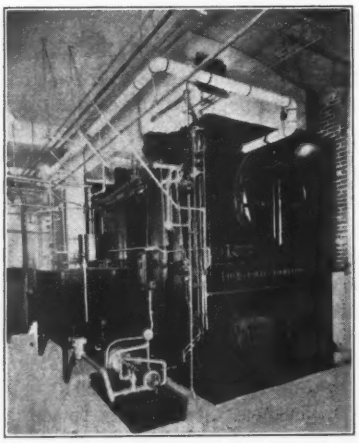
FIGS. 1 AND 2. BEFORE AND AFTER
Conventional type fan on left required a great deal of space which crowded the ash tunnel and cramped service pipe and wiring facilities. Propeller fan on the right requires no more space than discharge duct of large fan and is easily installed. Propellers with internal motor mounting of this 30,000-c.f.m. fan shown by headpiece

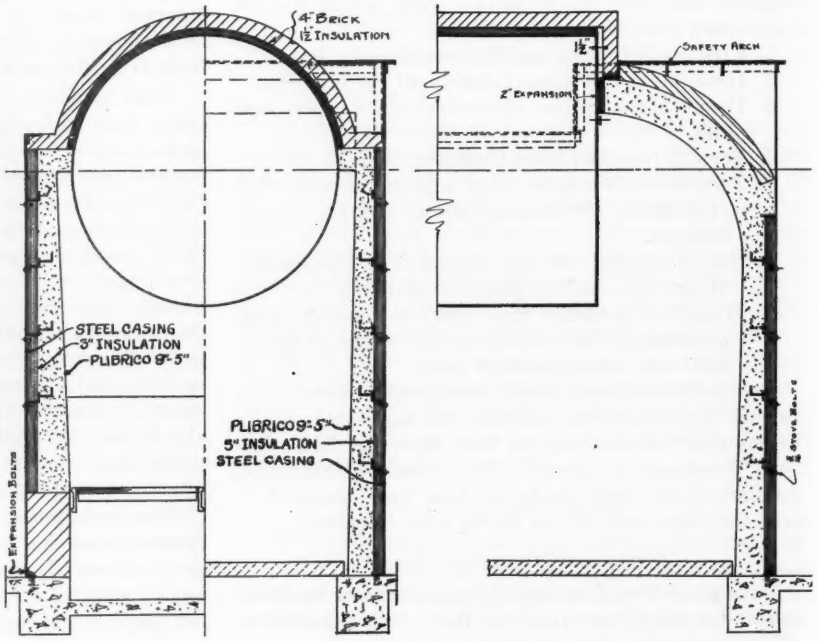
Steel Cased Boiler Settings

NEW BOILER INSTALLED BY KRAFT-PHENIX CHEESE CORP. GOOD EXAMPLE OF MODERN SMALL BOILER DESIGN

SMALL BOILER DESIGN and installation is fast catching up to the standards set by large units. A good example of this is the recent installation of a 95-hp. Nuway boiler installed at the new Atlanta plant of the Kraft-Phenix Cheese Corp. This unit equipped with a Copes feedwater regulator has a complete steel cased and insulated Philbrico setting. The neat appearance is apparent in the photograph which shows a small boiler room which any company would be proud to have as a show place for visitors.

Steel cased settings have several advantages not the least of which is the positive elimination of air infiltration. Maintenance is reduced to a minimum as the cracking and deterioration of the brick setting is done away with, leaving only an occasional coat of paint to be applied to the steel.





DETAILS OF STEEL CASED SETTING AND PHOTOGRAPH SHOWING THE NEAT APPEARANCE WHICH IT GIVES THE SETTING

Heat losses are reduced because this well constructed setting is insulated inside of the steel work and this insulation stays in good condition as long as the refractory lining is maintained. There are no joints or ledges to collect and hold dust and an occasional coat of paint keeps the boiler room bright and clean.

A typical steel cased furnace with plastic refractory is shown by the sectional drawings. At the left is a section through the firebox showing the refractory, running from 9 in. at the bottom to 5 in. at the top, with 3 in. of insulation backed by the steel casing. This thickness of insulation is usual for average conditions. At the extreme right is the detail of the rear arch showing a safety deck.

Less floor space is required with this design as the setting can be made 18 in. narrower in width. Furthermore the weight is materially reduced over the brick setting resulting in a material saving in foundation costs especially where soil conditions are poor.

When resetting old brick-set boilers, the supports can generally be moved so that the casing can be bolted to them while old fronts can be utilized by drilling holes so that new parts of the casing can be bolted to it. Lug set boilers can be adopted to this type of casing by swinging the boilers from gallows frames by means of U-bolts attached to the lugs.

TOTAL CAPACITY of water wheels at water-power plants in the United States on January 1, 1932, according to the annual report just released by the Department of the Interior through the Geological Survey, was 15,562,805 hp., an increase during the year of 681,000 hp., or 4.3 per cent.

Capacity of water-power plants in the later part of 1921 was 7,927,000 hp. In the ten years since 1921, the capacity has practically doubled and the increase has averaged about 760,000 hp. a year. This average growth is noteworthy, because during this same period the development and inprovement of steam power-plant equipment and the increase in the efficiency of operation of steam plants have been almost phenomenal.

Capacity of water-power plants as given in this report shows that there was an increase of 25,000 hp. or more during 1931 in each of the States of Maine, Pennsylvania, Georgia, Missouri, Arkansas, Washington and California.

The complete report shows the total capacity of water wheels in plants of 100 hp. or more by States and main divisions of the United States, segregated between public-utility companies and manufacturing companies, the trend in development in different sections of the country and the rank of the 10 leading States in developed water power from 1921 to 1932. Copies of the complete report may be obtained upon application to the Director, United States Geological Survey, Washington, D. C.

Power Utilization

Cost of High-Pressure Blowing

FITTING EQUIPMENT TO ITS WORK DEMONSTRATED TO BE PROFITABLE

JACK HUGHES, the plant engineer, just returned from his vacation, was taking a walk through the various departments when he met Fred of the piece-rate department.

"Have a good trip, Jack?" asked Fred.

"Dandy; fishing, swimmin' and everything. First real vacation I've had in years but at that the four weeks went mighty fast," replied the well tanned man.

"That's fine, you surely deserved it. But say, the old man wants to see you. He seems peeved about something.—Better go get it over with," said the younger man as he hurried along to time a new job on a spring hammer.

Five minutes later, Jack Hughes rapped on the door of the office of the manager and entered.

"Good morning, Mr. Maxwell," he said pleasantly.

"Morning, Hughes. Back from your vacation, hey?" answered the manager curtly.

"Did you want to see me about something?" asked the engineer.

"Yes. I've been looking things over a bit while you were away and I find that other departments have been reducing their costs but our power house expense is rising. Anything to suggest?" said the manager pointedly.

"Let's see!" answered Jack thoughtfully. "I was just in the forge shop and happened to notice that the four new spring hammers have been equipped with scale blowers that are connected to the air main."

"Well, what else should we have connected them to—the water main?" snapped the manager.

The engineer took a good look at the man opposite him for it was an unexpected answer.

"Mr. Maxwell, if you are busy I'll come in some other time. What I was about to suggest was that we put in a small blower to supply the air for the four scale blowers," explained the engineer.

"That's just it, Hughes. Every once in a while you get off the track. Here you are worrying about a few cents when there's losses that if not stopped will amount to hundreds and hundreds of dollars a year. It's the big, important things that we must look after.

"Suppose we do use a dollar's worth of air a week —what of it? We compress it to be used anyhow. I authorized the installation of those blowers just after you went West. They're only about a ⅛-in. diameter hole and too insignificant to bother with right now—"

"Just a minute," interrupted the engineer. "Let's talk facts. That air line is fed from a 100-lb. air compressor that takes a little over 90 hp. motor input when handling 375 cu. ft. of free air per minute. I know that because we ran a test last year. That means we're compressing just over 4 cu. ft. of free air per minute or 240 ft. an hour per horsepower. Better call it 4 cu. ft., now because the compressor has probably worn a little and the valves are perhaps not seating as good as they were. Now our cost for a motor horsepower is three cents an hour to handle 240 cu. ft., therefore we are getting, say 80 cu. ft. of free air compressed to 100 lb. for one cent. Is that clear?"

"Yes, that's clear enough and it goes to prove what I have just told you. The cost is insignificant. Why for a dollar we get 8000 cu. ft. of air and that's over five times as much air as there is in my office right now," answered Mr. Maxwell.

"Wait a minute," said Jack, "let's go a bit deeper. Those nozzles are nicely tapered and the orifice is 5/32 in. in diameter. I know that because I just measured one. According to test tables, a nozzle of that size on a 100-lb. air line will discharge 40 cu. ft. of free air a minute so the four blowers will pass 160 cu. ft. of air every minute, or 9600 cu. ft. an hour. That's $1.20 an hour if you want it expressed in money and as you know, those hammers are expected to run 2500 hr. per year. So the cost of those nozzles will be 2500 times $1.20 or $3000 a year. You wouldn't call that insignificant, would you?"

The manager looked at Jack Hughes with surprise for it was a much greater expense than he imagined, although he was not prepared to admit it.

"Just the same," he said, "we've got to blow the scale away. We can't turn out quality stuff with the scale all hammered into it. How else would you suggest we do it?"

"There's no need to use 100-lb. air pressure for that work. Why not install a small direct-motor-driven blower for that job,—say one that gives 16 in. of water pressure? There are some nice little units on the market," said Jack.

"A lot of good that'd do. Why, I can blow a darn sight more pressure than that and I know I couldn't clean scale off that way."

"That's because you're overlooking the question of volume. A properly designed nozzle working at even 14-in. pressure will give a nozzle velocity of over 150 mi. an hour and that's a higher speed than any cyclone goes to blow autos, trolleys and even freight trains about. You've simply got to get enough air delivered."

"Well, how much of this 16-in. pressure air can we get for a horsepower then?" asked the manager.

"Those small units I was telling you about will deliver over 200 cu. ft. per min. for a horsepower or 12,000 cu. ft. an hour. At 3 cents a horsepower-hour, that's 4000 cu. ft. for one cent at our cost," explained the engineer.

"That's all right so far but how much air would each nozzle have to deliver? You couldn't begin to

use those 5/32-in. ones at that pressure and get anywhere," said the manager, who was not yet willing to admit he had ordered something done that was not financially sound.

"Why, we ought to deliver at least as much air at the lower pressure, perhaps even a little more—say around 50 cu. ft. a minute," suggested the engineer.

"That would be about a ⅜ in. diameter nozzle, wouldn't it?" guessed the manager.

"Oh, it would have to be larger than that for so much lower pressure. Anyway it's easy to figure," said Jack, taking a little memorandum book out of his pocket. "Here's the standard formula for nozzles: Cu. ft. air per min. = $1096.5\ CA_1 \sqrt{(P \div W)} \times \sqrt{[1 \div (1 - [A_1 \div A_2]^2)]}$ Now C is a constant depending on the orifice and for a well made 13 deg. included-angle nozzle it is 0.985. A_1 is the area in square feet of the nozzle which we will assume at ¾ in. or—" and he ran the figures through on his slide rule—"0.0031 sq. ft. P is the pressure of the air in inches of water and in this case we will allow a friction loss of 2 in. from fan to nozzle, which will be ample if the piping is properly designed. That will give us 14 in. at the nozzle entrance. W is the weight of the air per cubic foot and at 14 in. and 70 deg. that is 0.0775 lb. A_2 is the area in square feet of the pipe delivering to the nozzle which will be about 1½ in. diameter or 0.01227 sq. ft. in area. Now we can put the figures in the formula to suit our problem: Cu. ft. per min $= 1096.5 \times 0.985 \times 0.0031 \sqrt{(14 \div 0.0775)} \times \sqrt{[1 \div (1 - [0.0031 \div 0.01227]^2)]}$.

"Looks too complicated," remarked the manager as the engineer was quickly figuring.

"Oh, it isn't difficult at all," protested Jack. "Look I'll put each step down: Cu. ft. min. $= 3.345 \sqrt{180.7} \times \sqrt{1.068}$. That simplifies to : Cu. ft. min. $= 3.345 \times 13.42 \times 1.034$, and the answer therefore is 46.7 cu. ft. per min. That's plenty near enough, so call it 50 cu. ft. a min. Now let's see how much the four nozzles will cost us, per hour. The air delivery will be 4×50 or 200 cu. ft. a min. which takes one horsepower and costs three cents an hour. The power cost for 2500 hr., therefore, will be $75. By making this change the actual saving a year will be $3,000—$75 = $2,925 and that will go a ways to reduce the hundreds of dollars expense increase you were speaking of a short time ago."

"My gosh, Hughes, I never realized we were wasting so much money with those four little nozzles. You go right ahead and make any changes you want," said Mr. Maxwell smiling.

Storage of Lubricants

By Allen F. Brewer

CERTAIN DETAILS in the practice of industrial or power plant lubrication may frequently be the cause of decidedly unsatisfactory service, for they will vitally affect the degree to which the lubricants involved will function as intended. These will comprise: improper storage; careless handling; faulty application and lack of appreciation of lubricating requirements.

Extension of any study of lubrication to the several fundamental features, which in the end will determine the degree of success which can be attained from the use of any particular lubricant, requires first of all consideration of storage methods and facilities and elimination of improper practices.

In this connection, says Lubrication, published by The Texas Co., initial protection is essential. As a result, wherever a considerable volume of lubricant is used, a central oil storage house should be provided or at least a special room should be reserved in some part of the plant from which lubricating oils and greases can be issued to the various departments on requisition, in suitable though not excessive quantities. In turn, all new supplies of such oils should be delivered here for storage until required, to insure the utmost protection against contamination.

Choice of Storage Location

Justification for the construction of an independent oil house will depend, of course, to a great extent upon the amount of plant equipment to be lubricated. Naturally, there will be considerable expense attached to such an installation. For this reason, many plants adjacent to oil supply stations set aside a corner of the engine room or storehouse for the storage of lubricants and keep them in shipping containers until empty, when they are returned to the oil dealer.

An objection to such oil storage, however, is that there will be considerable possibility of contamination of the lubricants, especially where plant cleaning is done in a careless manner, resulting in the possibility of dirt being swept or hosed into drip pans and measures. There will also be considerable chance for leakage and wasting of oils in such a room, unless an unusually careful employe has sole and complete charge and keeps the supply inaccessible to others.

Situation in the Plant

Considerable attention should be given to the plant location of the oil house or the part of the storehouse or power house which is to be set aside for an oil room. First thought should be to locate the oil room or house as close as possible to the railroad siding, dock or street, to avoid loss of time in the laborious handling of heavy oil containers. Furthermore, considerable damage may be done to lubricants and containers if the latter are rolled or tumbled about unnecessarily. Where storage is properly located, containers will be subject to no more handling than absolutely necessary in their transfer from cars, boat or motor truck.

Hoisting of filled containers from one level to another, whether done by hand or elevator, is expensive and entails a certain amount of severe handling of the containers, which may easily lead to contamination of the oils or greases through sprung seams. Wood barrels,

*Technical Division, The Texas Co.

especially, will suffer warped and cracked heads, or particles of the glue lining will often jar loose. For this reason, any damage to the container which may break the seal and lead to contamination of the contents through entry of water or foreign substances is a serious matter.

Advantages of One Level

To prevent this as far as possible, one-level handling is always best. In other words, where practicable the platform of the oil house or storage room should be on a level with the car floors or dock or, where containers are to be delivered by motor truck, on a level with the floor of the average truck. Under such conditions, containers can be rolled, trundled on hand

FIG. 1. INDIVIDUAL TANKS FOR STORAGE WITH HOIST FOR EMPTYING DRUMS INTO TANKS

trucks or handled by a portable conveyor, directly from the delivering medium to the filling hatch of the storage tanks, where this is located at the floor level or to the hoisting device above the tanks if they extend above the floor. A minimum of labor, lost time, damage to containers and waste or contamination of the lubricants will be the result of such a layout.

Construction Details

Whatever the method of storage, the general construction of the oil house should be fireproof throughout, with brick, tile or concrete walls and floor. The roof should be tile, metal or slate on steel beams or rafters. Danger of fire in a modern oil storage house will usually be negligible, yet fireproof construction features are the best insurance and first cost, unless prohibitive, should not be spared. In addition, such construction will be much easier to keep clean than woodwork, which will soon become splashed and oil-soaked.

Doors and windows also require consideration. Best practice recommends as few of these as possible and those that are used should be of steel-frame or roller type, fitted with wire glass and automatic closing devices. A final precaution is the installation of suitable fire extinguishing equipment.

With an understanding of the features that a modern oil house or storage room should embody, the question of storage tanks and their appurtenances requires consideration. In any plant the type, size or number of storage tanks will depend upon the volume and nature of the lubricants to be stored. In general, where an oil house is involved, it will usually be practicable to build it with a basement and to provide for bulk storage tanks there; the main floor in such a house would thus serve as the receiving and delivering room, the tops of the tanks projecting above the floor or not, according to their design. Many lubricating engineers prefer to keep all tankage below, devoting the entire floor level area to delivery pumps and other necessary accessories.

The number of such tanks required will depend, in general, upon the number of different grades of lubricants necessary for plant operation. In every case, the rate of plant consumption should be considered. Where small quantities of certain products are to be stored for any length of time, it will be best to keep them in the shipping containers over the period of storage, in

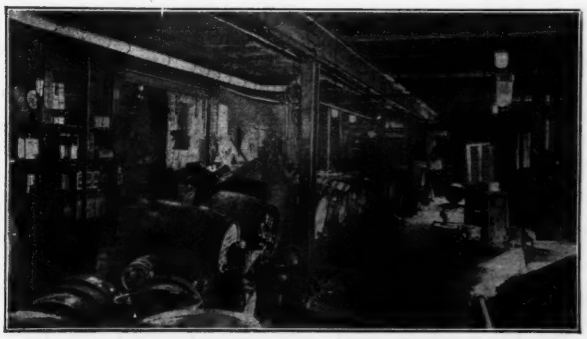


FIG. 2. DISORDERLY STORAGE IN BARRELS AND CANS FAILS TO PROTECT LUBRICANTS FROM CONTAMINATION AND WASTE

the interest of economy of space and expense, rather than to plan for transfer to permanent tanks. In the case of semi-solid lubricants, transfer would necessitate some form of heating system to bring about temporary liquefaction. As a result, unless such products are received in lots of several barrels, as in steel mill or railroad service, it will be best to store them in the shipping drums.

If a transformer winding is equipped with a properly designed electrostatic shield, voltages of all surges will distribute uniformly and oscillation or resonance will not occur. This is the principle utilized in the present day non-resonating type of transformer. To demonstrate the lightning strength of such a transformer, one of fourteen 13,000-kv-a., 230-kv. transformers was subjected to artificial lightning. Over 200 surges were applied. Forty were in excess of the flashover voltage of a 64-in. coördinating spark gap. The transformer withstood all of these tests successfully. A few of the surges were full waves just below the flashover of a string of 14 standard suspension insulators. A few were waves just below flashover of the transformer bushings. Also, a few were high enough to flashover the bushings. To be certain that no damage was done by these tests, the transformer was completely disassembled for examination. The tests were preceded and followed by complete A.I.E.E. acceptance tests including a 460-kv. induced potential test.

POWER PLANT ENGINEERING March 15 1932

Vacuum Refrigeration Opens New Field of Use

FLASH EVAPORATION SYSTEM OPERATES WITHOUT MOVING PARTS AND USES NO INTERMEDIATE REFRIGERANT. CAN BE USED WHERE STEAM AT 15 LB. GA. OR HIGHER IS AVAILABLE. BY D. K. DEAN*

COOLING WATER at temperatures ranging from 32 deg. to 50 deg. for the final cooling of the product is essential in many processes. Other industries, of which the manufacture of chocolate and explosives are typical, require conditioned air at moderate temperatures and with low humidity. Cool water is essential for dehumidifying. Cooling of air for theatres and public buildings is becoming common practice in warm climates. Such air cooling and dehumidifying requires a supply of cool water. Many such recent developments have increased the field for refrigeration systems of moderate cooling capabilities.

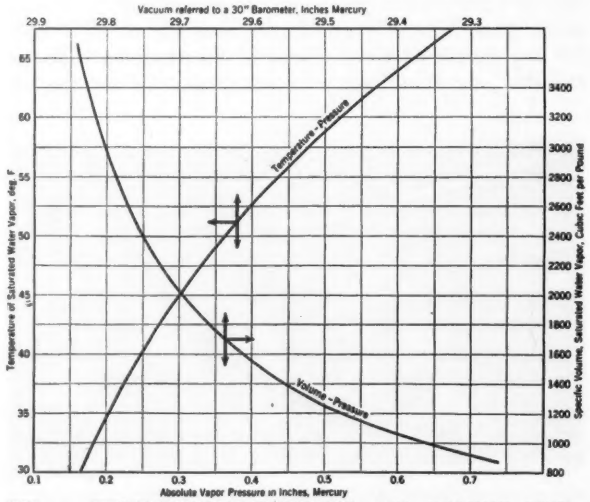


FIG. 1. TEMPERATURE-PRESSURE AND VOLUME PRESSURE CURVES FOR WATER

A vacuum refrigeration system for maintaining water at low temperatures has been developed, which system can be installed wherever there is a supply of steam for operating the equipment. Operating principle of this system is flash evaporation. The water to be cooled is piped into a chamber in which a high vacuum is maintained. It is obvious that, if the water delivered to the vacuum chamber is warm and the vacuum is high, the reduction in absolute pressure of the water will cause the water to boil, evaporating a portion of it. Vapor which is liberated from the body of the water absorbs latent heat of vaporization from the liquid introduced into the flash chamber. Abstraction of this heat cools the remaining water to a temperature which corresponds to the absolute pressure in the flash chamber. The curve in Fig. 1 shows graphically the pressure-temperature relations of saturated water vapor at extremely low absolute pressures. It also shows the specific volumes of water vapor at low pressures.

VAPOR COMPRESSED BY STEAM JET

Principle of flash evaporation may be comprehended easily by a study of the following example. Let it be assumed that a pound of water at a temperature of 55 deg. F. is introduced into a flash chamber in which an absolute pressure of 0.3 in. mercury is maintained. Let X = fraction of water vaporized. Steam tables show the latent heat of vaporization at 0.3 in. abs. pressure of mercury to be 1066.1 B.t.u. per lb. The heat absorbed by vaporization therefore will be 1066.1X. The curve, Fig. 1, indicates that saturated steam at 0.3 in. mercury absolute pressure has a temperature of 45 deg. F., which will be the temperature of the water in the flash chamber.

Assuming the specific heat of the water to be equal to 1, the heat given up by the water will be (55-45) B.t.u. for each pound of water introduced into the flash chamber.

Then $1066.1X = (55-45)$ or $X = 0.00938$. Thus a little less than 1 per cent of the water introduced will flash into vapor and cool the remainder of the water 10 deg. to a final temperature of 45 deg. F.

In order to maintain an absolute pressure of 0.3 in. of mercury, it will be necessary to remove the water vapor as fast as it is formed. The curve shows the specific volume of a pound of water vapor to be 2033 cu. ft. at an absolute pressure of 0.3 in. mercury. The volume of vapor to be removed from the flash chamber will be $0.00938 \times 2033 = 19.1$ cu. ft.

Under the assumptions made, if this 19.1 cu. ft. of water vapor is removed from a chamber so as to maintain in the chamber an absolute pressure of 0.3 in. mer-

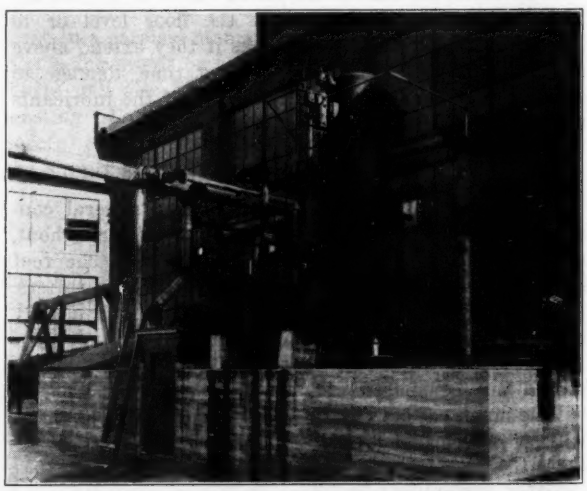


FIG. 2. A 75-T. UNIT IN SERVICE

This cools water for process work in a plant with a large demand for process heat. The refrigeration system is used as a heat pump, increasing the pressure and temperature of vapors recovered from the vacuum system enough to make the heat available for process work. The 900,000 B.t.u. per hr. taken out of the cooled water and the heat in the steam used for operating the thermo-compressor raise the temperature of the condensing water preliminary to process usage. The value of the heat recovered is such as to render the cost of refrigeration practically zero. The picture shows the entire equipment with the exception of removal pumps for the condenser and flash chamber. Parts may be identified by Fig. 3

*Foster Wheeler Corp., New York, N. Y.

cury, a pound of water introduced into this chamber at a temperature of 55 deg. will be cooled to 45 deg., leaving approximately 0.99 lb. water available in liquid state at this lower temperature.

In order to produce the very low absolute pressures, a steam operated thermo-compressor is used. This consists essentially of a group of high efficiency steam nozzles directed toward an entraining throat. Arrangement of the complete equipment is shown by Fig. 3. The thermo-compressor suction connects directly to a flash chamber and discharges directly into a high vacuum condenser which, in turn, is served by a small two-stage steam jet air pump. Two tail pumps are provided, one for removing the cooled water from the flash chamber and one for removing the condensing water from the condenser. If it is assumed that the normal supply of condensing water is at a temperature not ex-

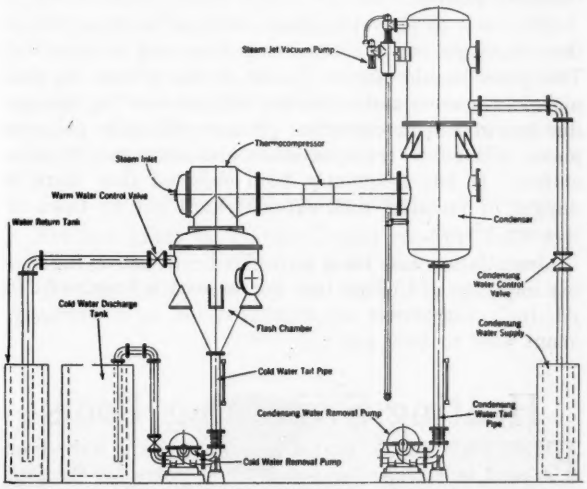


FIG. 3. DIAGRAM OF THE EQUIPMENT USED IN A TYPICAL VACUUM REFRIGERATION SYSTEM

ceeding 80 deg. F., it would be possible to maintain within the condenser a vacuum corresponding to 2 in. absolute pressure mercury. Under the conditions assumed in the example, the duty of the thermo-compressor would be to remove 19.1 cubic feet of water vapor from the flash chamber for each pound of water introduced into the flash chamber and to compress this vapor to an absolute pressure of 2 in. mercury within the condenser. At this pressure the vapor could be condensed by the 80 deg. F. condensing water.

Industrial Applications

As compared with other types of refrigeration it is to be noted that the cooled water is refrigerated directly without the necessity of an intermediate refrigerating medium such as ammonia or sulphur-dioxide and the cost and difficulties of handling such media are eliminated. The apparatus operates under a vacuum and is not subject to the danger of explosion as are some other systems. No noxious or poisonous vapors can escape from the system as none are used. There are no moving parts except the rotors of the two centrifugal pumps.

This system of refrigeration is especially adapted for the following types of installation.

Air conditioning in industrial plants and in semi-public places in which there is steam power and a supply of condensing water.

In the dairy industry for milk cooling, it has the advantage of serving milk coolers with low temperature water without the danger of freezing the coils. The apparatus can be designed so as to maintain a low temperature without cooling below the freezing point.

Silk and rayon dyeing. Low temperature water can be produced continuously for dyeing. In such plants the heat used for operating the thermo compressor as well as the heat abstracted from the water cooled, can ordinarily be used in the process. The value of the heat recovered from the cooled water may be enough to counterbalance the other costs of operation of this equipment, thus rendering the net operating cost of such a combined refrigeration and heat recovery system practically zero.

Paper industry. Cooled water for the finishing rolls of newsprint machines is oftentimes of value.

In sulphite mills for acid recovery systems. Approximately 75 per cent more sulphur-dioxide can be absorbed with water at a temperature of 40 deg. F. than can be absorbed with water at a temperature of 70 deg. F.

Rubber industry. Cooled water is especially useful for cooling the final rolls of a rubber mill, thus avoiding decrease in production which frequently occurs in this industry because of the high temperature of normal cooling water through the summer months.

Gas industry and Benzol recovery plants. Low temperature water for the final coolers of Benzol recovery plants will greatly increase the recovery of condensable products.

Low temperature water is also useful in illuminating gas systems for condensing out resinous products which are sometimes found in illuminating gas.

Textile industry. This equipment is especially adaptable to mercerizing plants. The lye solutions used in the process may be cooled to a temperature between 35 and 40 deg. by introducing the solution directly into the flash chamber. Since the lye solutions ordinarily are diluted in the process, the flashing off of some of the water in the flash chamber will tend to maintain the proper concentration of the solution.

Oil refineries. For the precooling of paraffine distillates and wax prior to actual refrigeration necessary for the recovery of wax. As a pre-cooler, this device will reduce appreciably the load on the main refrigeration equipment with a consequent increase in economy.

The device is also applicable for condensing and cooling of the extremely light ends in gasoline vapor recovery.

In his wretched life of less than 27 yr. Abel, the mathematician, accomplished so much of the highest order that one of the leading mathematicians of the Nineteenth Century could say without exaggeration, "Abel has left mathematicians enough to keep them busy for five hundred years." All this was done in seven working years "by studying the masters."

Considerable progress has been made by the manufacturers in supplying self-contained motor control groups completely fabricated in the factory. In many instances where the field labor costs are high, a substantial saving can be made by using factory fabricated control groups.

Pipe Line Transportation of Powdered Material

2000 Yd. at 65 to 130 Ft. Per Sec. By Fredrich Schulte*

TRANSPORTATION of pulverized coal for great distances in pipe lines is done exclusively by pneumatic methods in Germany. Before the introduction of pulverized coal firing in Germany, this method of transportation had been applied to bulk materials, grain, ashes and the like. Pneumatic conveying can be done either by suction or by compressed air.

In general, suction operation is preferable but it can be used only for distances up to 450 yd. Pressure must be used for greater distances but this can be used only up to 2000 yd. For still greater distances, intermediate stations must be installed. In many cases suction and pressure operation are combined.

Large pipe cross sections must be used, as a large amount of air is necessary for transportation. Depending on the length of pipe, the air consumption is between 4200 to 10,000 cu. ft. air per long ton of pulverized coal, or 1.5 to 6 per cent of the air required for combustion.

Naturally, the intimate mixture of air and dust increases the danger of explosion in the transporting installation, especially with high-volatile and easily ignited coals such as brown coal; consequently transporting installations for brown coal use an inert gas such as flue gas. In this case, a circulating system is adopted so that the gas is used over and over again. Because of the danger of explosion when using air for transporting easily ignited dust, the pipe-lines should not be placed in the vicinity of open flames or objects that radiate heat strongly, such as furnaces, ovens or boilers. They also must be grounded and electric wires should not be hung from them.

Moisture and Fineness

Return pipe circuits mentioned above have the advantage that the gas or air can be heated in order to prevent the moisture in the coal and air from condensing on the inside walls of the pipe-lines. It is recognized that condensation of water in pipe-lines causes adherence of the dust, therefore rapid clogging and considerable trouble. In addition, the power consumption is higher with moist dust than with dry dust. In a plant built for a capacity of 10 to 15 long tons of pulverized coal per hour, a moisture content of 5 per cent in the dust reduced the actual conveying capacity to only 5 to 6 long tons per hour. In addition to the requirements for minimum moisture content, a certain fineness of the dust must be observed. Ordinarily a dust with a residue of 1 per cent on the sieve with 76-mesh to the inch is required.

It is important that the lines be straight with as few bends as possible and that the gradient be as uniform as possible without abrupt transitions. In rebuilding one installation the number of bends was reduced from 14 to 3, resulting in a power saving of 30 per cent.

With the high velocities, 65 to 130 ft. per sec. generally used, there is considerable wear in the pipe-lines. In one plant that operated 24 hr. a day, the bends had to be renewed after 2 yr.; consequently it is advisable to make the bends with rather large radii so that the power consumption and wear will not be too great. In addition, they should be made so that they can be replaced easily, or with removable sections. Frequently the outside of the bend is provided with a cement back. In an installation operating under normal conveying conditions, using a pipe diameter of 8 in. and an air velocity of 65 ft. per sec., it was necessary to make a replacement after conveying 130,000 long tons.

Leaks can be located easily and, naturally, they must be repaired immediately. In suction operation one hears plainly the sucking of leakage air and in pressure operation the dust is blown from the line. Both represent losses that must be reduced to a minimum by regular inspection. It is easiest to weld a strip of iron on the damaged places.

It is best to place the pipes overhead on supports, so that thorough inspection and easy repairing are possible. The pipes should not be placed in the ground as this makes inspection and repairing difficult and the damage due to water is considerable. Water will easily enter at leaks, will affect transportation and may stop it altogether. It has frequently been objected that there is danger of freezing with exposed lines but no cases of this are known.

Installation cost for a pulverized coal conveying system capacity of 15 long tons per hr. and a length of 270 yd., including blower but without motor, is, in Germany, about $340 to $430 per t.

*Director of the Association of Supervisors of the power industry of the Ruhr District, Elsen, Germany. From a paper presented before the Third International Conference on Bituminous Coal, Carnegie Institute of Technology, Pittsburgh, Pa.

Heating Swimming Pools

ELECTRICALLY heated swimming pools have been used in Europe for a number of years for the purpose of using offpeak current. Two of the baths described in a recent issue of Siemens Review state that the water is filtered and sterilized and that only 10 or 20 per cent of the water is changed each week, the exact amount depending upon the number of persons using the pool.

When the water is changed a certain amount is run off and replaced by fresh water electrically heated to 68 deg. F. This water is heated during the night only. The first pool of this type was built in Vienna in 1926 and has a volume of 165,000 gal. The electrode circulating heater has a capacity of 465 kw. of 5000 v. 3 phase alternating current; no transformer used with the installation; circuit breakers provide three overload trips and no voltage release. Capacity of the heater can be adjusted by altering the position of the electrodes. Water does not flow directly into the circulating heater but is first taken to an intermediate tank of about 450 gal., equipped with a ball float valve. Amount of water fed to the electrode heater is regulated by means of valves which are set to pass required amount of water before the circuit breakers close.

The second pool in Vienna, with a capacity of 730,000 gal., is also warmed by electrode circulating boilers but these are rated at 800 kw. For heating the initial filling of the basin from 47 to 68 deg. F., about 60 hr. are required; first heating made with only 660,000 gal. is performed in four and a half night periods of 12 hr. each.

Modern Welded Pipe Installation

STRONG JOINTS, SPACE ECONOMY, FLEXIBILITY AND SPEED OF ERECTION ARE ADVANTAGES

INCREASING USE of welded construction for piping systems is the result of its inherent advantages and of development along sound engineering lines. Use of various types of fittings designed especially for welded construction has enabled the engineer to use improved designs, as illustrated in a recent heating installation for a large building in the middle west where all piping over 1½ in. diam. was oxy-acetylene welded in accordance with established standards.

VEE BUTT JOINTS USED

For line joints the standard open vee butt weld was specified as shown in Fig. 1, a joint easily and economically made and proved by test to be the strongest of

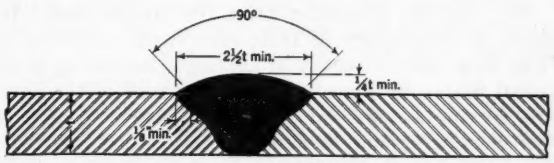


FIG. 1. DETAILS OF VEE BUTT WELD

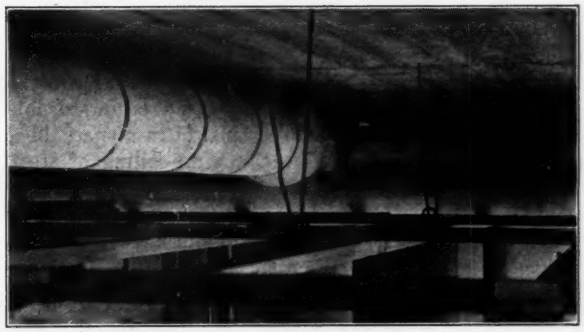
many types. Pipe is supplied by manufacturers with the ends beveled 45 deg. to a $\frac{1}{16}$-in. inner flat as shown by dotted lines. The flat facilitates lining up and depth of penetration of the weld. When lining up for welding, a space is left between ends as shown to allow them to draw together as the cooling weld metal contracts, without overlapping of edges or undue residual stress.

In design, no allowance is made for this spacing as, after welding, overall lengths will be true within construction tolerances. For added safety, a bead is built up on the outside, of minimum width 2½ times the pipe wall thickness and extending ¼ that thickness above the pipe, sloping down to the pipe surface as shown. This weld is recommended for standard, extra heavy and double extra heavy pipe for all services and pressures.

FITTINGS AND CONNECTIONS

Tees, crosses and branch connections were made from standard pipe by cutting with a blow pipe, then welding in place. Templets were used to get accurate cutting and ends of branches cut so that they could be inserted into the opening down to the inner surface of the main pipe wall, edges of the opening being beveled to give a good vee for welding.

Standard fittings for welding include short radius bends, forged reducers and forged high-hub flanges. The



12-IN. MAIN WITH ECCENTRIC BRANCHES PLACED IN 14¾-IN. SPACE BETWEEN FLOOR AND CEILING

bends are forged to shape from seamless steel tubing with uniform curvature and wall thickness and true circular cross-section at all points. High-hub flanges are forged steel with a beveled hub of length such that the end may be welded to the pipe without distortion of the flange face. Reducers are of forged steel, beveled at each end, for welding into the pipe line where change of diameter is desired. Use of these fittings allows novel arrangement in design.

MAIN HEADER CONNECTIONS

Four 250-hp. boilers supply steam to some 50,000 sq. ft. of direct radiation, several unit heaters and a central blast system. The header is two 16-ft. lengths of 16-in.pipe, welded together and the ends blanked by ¾-in. flat plate discs welded in. Four 10-in. boiler leads and three 12-in. supply mains are connected by welding short-radius bends into openings in the header, Fig. 2, turning the outlet in any direction desired. One 12-in. main was taken off at 45 deg., the others at 90 deg. For a smaller main, connection was made by welding a straight nozzle with bend at its upper end. High-hub flanges were used in making connections at the boilers.

By this construction, the overall height, including all connections, was reduced to 34 in. and weight to 2650 lb., with cost considerably lowered.

FIG. 2. 16-IN. HEADER WITH BOILER LEADS AND SUPPLY MAINS WELDED IN

Close Work on Mains

Originally, mains for the distribution floor were planned exposed, with no room left for the space usual for concealing piping. This floor was redesigned to be used for offices, so that exposed piping was undesirable and the main and branches were placed in a space 14¾ in. high, after allowing for a hanging ceiling of steel, lath and plaster below the pipes. As the main was 12 in. in diameter, this left only 1 in. clearance below and above the main, hence runouts to the branch risers were welded into the main, eccentric as shown in the headpiece to provide drainage of the condensate from the main. The main was fabricated on the floor in 40 to 80-ft. lengths with short connections for branches welded in. These sections were raised and hung a few inches

FIG. 3. RECTANGULAR EXPANSION LOOP FOR NEATNESS AND SMALL SPACE

below final positions by long hanger rods. This provided space for making the position welds, after which the main was raised to final position by screwing up the hanger nuts and the surplus hanger rod was cut off. Evidently welding was the only method by which this job could have been constructed.

Expansion Loop

For welded systems, expansion and contraction are cared for by the usual loops but a rectangular arrangement of straight pipe and short bends, Fig. 3, was used, instead of the omega form, to conserve space and give a neat appearance. If the line is to be hot at all times, it is good practice when installing to spread the loops with a jack enough so that they will be in unstressed position when the line is at operating temperature. If the line is to be hot in winter and cold in summer, the loops should be spread half the above amount.

Tests of Welding

Before steam was available, all piping that was to be permanently concealed was given a 50-lb. hydrostatic test and joints carefully inspected. Before putting into service, all joints were given a hydrostatic test three times working pressure and hammered under pressure with a 2-lb. hammer. Finally the system was given a 50-lb. air pressure test while joints were painted with soapy water.

Operation of the system has been satisfactory, this success being ensured by procedure control in fabrication, whereby selection of material, details of fabrication and qualification of welders is definitely covered.

With modern methods as outlined, welding provides speed, flexibility, economy and dependability so that the use of welded systems is steadily increasing.

Dr. W. D. Coolidge Receives Washington Award for 1932

The Washington Award for 1932, "in recognition of devoted, unselfish and preëminent service in advancing human progress," was presented to Dr. William David Coolidge, associate director of the research laboratory of the General Electric Co. of Schenectady, following a dinner and reception on the evening of Feb. 24 at the Hotel Sherman, Chicago, Ill. Dr. Coolidge is the eleventh to be so honored by the Washington Award Commission, the first presentation being to President Hoover, in 1919. Dr. Harry Woodburn Chase, president of the University of Illinois, delivered the principal address of the evening, evaluating the importance of research in the present social order.

Among the best-known contributions of Dr. Coolidge are ductile tungsten for lamp filaments, wrought tungsten for contacts and X-ray targets, the hot cathode X-ray tube, various types of X-ray generating equipment, the "C" tube for submarine detection and signaling and the cathode ray tube. An exhibit of the achievements for which the award was given to Dr. Coolidge was on display at the hotel.

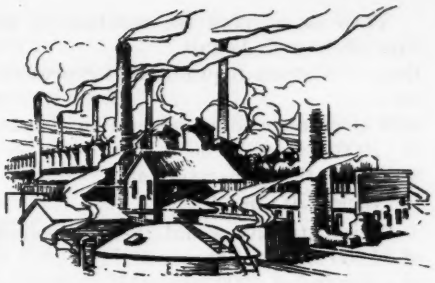
Dr. Coolidge graduated from the Massachusetts Institute of Technology in 1896, afterwards receiving his Ph.D. from the University of Leipzig. Returning to the United States, he joined the teaching staff of the Institute, serving as assistant in physics, instructor in physical chemistry, and as assistant professor of physicochemical research. In 1905 he became a member of the staff of the General Electric research laboratory under Dr. Willis R. Whitney and in 1908 was made assistant director of that organization, a position he occupied until 1928, when he was made associate director. The Washington Award, presented to Dr. Coolidge, was founded 16 years ago by John Watson Alvord and it is administered by the Western Society of Engineers. Presentation was made by Frank D. Chase, president of the society.

Power Engineers' Day

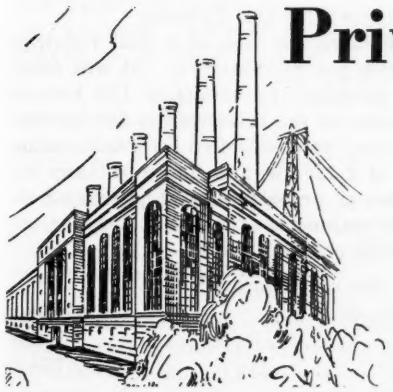
Philadelphia has set aside the entire day, Saturday, April 2, for the benefit of the engineering profession. It has been designated as Power Engineers' Day and an especially interesting program has been arranged. The local bodies of the N.A.P.E. and other engineering organizations—including the foremost engineers of this section—are intent upon making this an outstanding event in engineering circles.

Under the chairmanship of Herbert A. Russell, Superintendent of Power at the University of Pennsylvania, the following committee has arranged an interesting program: Dr. R. L. Martin, vice-chairman; Joseph D. Chapline, secretary; Samuel Jones, assistant secretary; N. Elwood Schultz, treasurer; Clifford Evans, Edward Green and Harry McKee.

Invitations have been extended to the power engineers within a radius of 100 mi. of Philadelphia.



Cooperation Between Private Plants *and* the Utilties



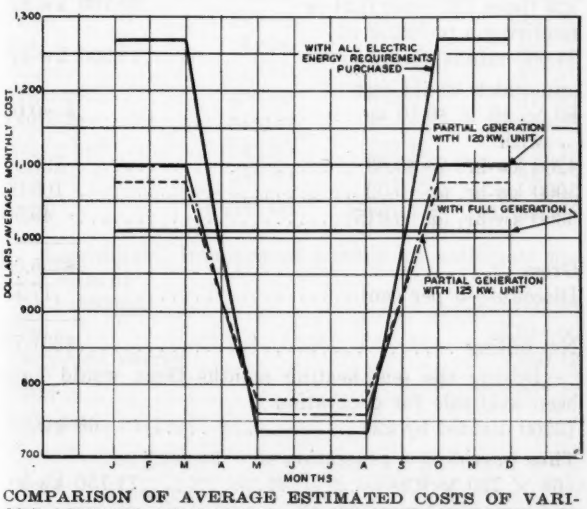
PART II

By OTTOMAR H. HENSCHEL
Consulting Engineer
Milwaukee, Wisconsin

IN A PREVIOUS article we began a discussion of several different schemes for reducing the power and steam costs in a factory devoted to the manufacture of wooden toys. In this article we considered two plans, one in which all the electrical energy was purchased from a public service company and another in which all the energy was generated by the company's private plant. With the first arrangement, it was shown that the unit energy cost was $0.0306 per kw-hr. while, with the second, the unit cost was $0.0299 per kw-hr.

Now, however, we shall discuss a still different arrangement which was analyzed, that is, an arrangement in which part of the energy is generated and part purchased. Under this scheme, the unit is operated in parallel with the system of the utility company and only an amount of electric energy generated consistent, as far as possible, with low-pressure steam requirements.

The initial step consisted of the consideration of a unit of 100 kw. capacity rating and having a water rate of 66 lb. per kw-hr., so that during the heating months there would be required for full load operation of the machine (100 times 66) 6600 lb. of steam per hr.



COMPARISON OF AVERAGE ESTIMATED COSTS OF VARIOUS SCHEMES CONSIDERED IN CONNECTION WITH TOY FACTORY POWER AND STEAM COSTS

Accordingly, then, by the use of a unit of such capacity, it was obviously estimated that a demand of 100 kw. would be created on the utility company's lines and that the monthly generation would amount to (100 times 720 times 0.24) 17,280 kw-hr. and thereby leaving for purchase 16,720 kw-hr.

Estimated cost of this purchased energy would then appear to be

100 × 10 × $0.10	$100.00
with	
4000 kw-hr. @ $0.03	120.00
5000 kw-hr. @ 0.02	100.00
5000 kw-hr. @ 0.015	75.00
1720 kw-hr. @ 0.010	17.20
Gross	$412.20
Discount—5 per cent	20.61
Or, a net billing of	$391.59

During the semi-heating months of April and September and as before indicated, there would appear available for electric energy generation, 3500 lb. of steam per hour and that with a possible generation of

3500 divided by 66 or ..... 53 kw.

which in time would provide per month an average of 53 times 720 times 0.24 or ..... 9158 kw-hr.

and necessitating the average purchase of

34,000 minus 9158 or ..... 24,824 kw-hr.

at a demand of

200 minus 53 or ..... 147 kw.

On the above basis, the monthly cost of this energy would appear as:

147 × 10 × $0.10	$147.00
with	
3530 kw-hr. @ $0.03	105.90
5000 kw-hr. @ 0.02	100.00
5000 kw-hr. @ 0.015	75.00
9824 kw-hr. @ 0.010	98.24
Gross	$526.14
Discount—5 per cent	26.30
Net billing	$499.84

Then considering the non-heating months of May, June, July and August.

Estimated steam requirement for process, etc.....1000 lb. per hr.
with a corresponding generation demand of (1000 divided by 66)..... 15 kw.
and a monthly generation of (15 times 720 times 0.24).....2600 kw-hr.

This naturally would then necessitate the purchase of 34,000 minus 2600 or.....31,400 kw-hr.
at a demand of (200 minus 15)..... 185 kw.
and at a cost of
185 × 10 × $0.10.....$185.00
with
3150 kw-hr. @ $0.03 ..... 94.50
5000 kw-hr. @ 0.02 ..... 100.00
5000 kw-hr. @ 0.015..... 75.00
16400 kw-hr. @ 0.010..... 164.00

Gross $618.50
Discount—5 per cent..... 30.92
$587.58

Then, with purchase of all electrical energy expected to be used in excess of generation capacity or low-pressure steam requirements the probable estimated cost appears as:

Month	Fuel Cost	Purchased Energy Costs	Total Costs
January	$ 648.00	$ 391.59	$ 1,039.59
February	648.00	391.59	1,039.59
March	648.00	391.59	1,039.59
April	354.00	499.84	853.84
May	112.00	587.58	699.58
June	112.00	587.58	699.58
July	112.00	587.58	699.58
August	112.00	587.58	699.58
September	354.00	499.84	853.84
October	648.00	391.59	1,039.59
November	648.00	391.59	1,039.59
December	648.00	391.59	1,039.59
Total	$5,044.00	$5,699.54	$10,743.54

The investment required in connection with the 100 kw. turbine-generator set appears to be as below.

Turbo-generator $3100.00
Switchboard 700.00
Installation including piping, wiring, etc..... 750.00
Total $4550.00
Resale value of old engine, line shafting and generator 750.00
Net cost $3800.00
With fixed charges as
Interest—6 per cent..... 228.00
Depreciation—5 per cent..... 190.00
Maintenance—5 per cent..... 190.00
Taxes and insurance—2½ per cent..... 95.00
Total ..... $ 703.00

Obviously, we can then expect a yearly cost for (34,000 times 12) 408,000 kw-hr. of energy
Fuel $5,044.00
Purchased energy 5,699.54
Fixed charges 703.00
Total $11,446.54

Thus will it be noted that by the installation and operation of a 100-kw. turbine-generator set and the purchase of all energy in excess of that obtainable from steam requirements the unit cost appeared to be equal to

$$\frac{\$11,446.54}{408,000} \text{ or, } \$0.028 \text{ per kw-hr.}$$

Employing 125-kw. Turbine

There was then taken the case of a unit requiring about 52 lb. of steam per kilowatt-hour. It was found that with such a machine approximately 125 kw. are available. The results of the investigation are interesting and for that reason were embodied for consideration.

While the case of a 125-kw. unit has been taken into account, calculations of probable cost of purchased energy to be used in conjunction therewith, however, are based on a generation of but 120 kw.

The initial cost of this unit appeared to be
125-kw. turbine-generator $5210.00
Switchboard 700.00
Installation 750.00
Total $6660.00
Credit for old existing engine, lineshaft and generator 750.00
Net investment required $5910.00
With resulting fixed charges as
Interest—6 per cent..... 354.60
Depreciation—5 per cent..... 295.50
Maintenance—5 per cent..... 295.50
Taxes and insurance—2½ per cent..... 147.75
Total $1093.35

With such a 125-kw. unit, coal costs, because of the lower water rate of the turbine, would apparently be the same as for the 100-kw. set: there would, however, be a difference in the amount of electric energy required to be purchased.

During the heating months, one could expect a demand equal to
200 minus 120 or ..... 80 kw.
with a generation of
120 times 720 times 0.24 or.....20,700 kw-hr.
requiring a purchase of
34,000 minus 20,700 or.....13,300 kw-hr.
and which would cost
80 × 10 × $0.10 or.....$ 80.00
with
4200 kw-hr. @ $0.03 ..... 126.00
5000 kw-hr. @ 0.02 ..... 100.00
3300 kw-hr. @ 0.015..... 49.50

Gross $355.50
Discount—5 per cent..... 17.75
Net billing $337.75

During the semi-heating months there would have been available for generation
(3500 divided by 52)..... 68 kw.
Thus providing a generation of
(68 × 720 × 0.24).....11,750 kw-hr.
and a required purchase of
(34,000 minus 11,750).....22,250 kw-hr.

Accordingly, the purchased energy costs would appear to be

Demand on purchase (200 minus 68)	132 kw.
132 × 10 × $0.10	$132.00
with	
3680 kw-hr. @ $0.03	110.40
5000 kw-hr. @ 0.02	100.00
5000 kw-hr. @ 0.015	75.00
7250 kw-hr. @ 0.01	72.50
Gross	$489.90
Discount—5 per cent	24.49
Net billing	$465.41

As indicated above, there appeared available for generation during the non-heating months, 1000 lb. of steam per hour, or approximately 20 kw. Thus, the purchased demand would be

(200 minus 20)	180 kw.
with a possible monthly generation equal to	
(20 times 720 times 0.24)	3500 kw-hr.
The required monthly purchase would then amount to	
(34,000 minus 3,500)	30,500 kw-hr.
and making the cost appear as	
180 × 10 × $0.10	$180.00
with	
3,200 kw-hr. @ $0.03	96.00
5,000 kw-hr. @ 0.02	100.00
5,000 kw-hr. @ 0.015	75.00
15,500 kw-hr. @ 0.01	155.00
Gross	$606.00
Discount—5 per cent	30.30
Net billing	$575.70

As a consequence, with a 125-kw. turbine set, the annual costs might be expected to be

Month	Fuel	Purchased Energy	Total
January	$648.00	$337.75	$985.75
February	648.00	337.75	985.75
March	648.00	337.75	985.75
April	354.00	465.41	819.41
May	112.00	575.70	687.70
June	112.00	575.70	687.70
July	112.00	575.70	687.70
August	112.00	575.70	687.70
September	354.00	465.41	819.41
October	648.00	337.75	985.75
November	648.00	337.75	985.75
December	648.00	337.75	985.75
Total	$5044.00	$5260.12	$10,304.12

Accordingly, it appeared possible to anticipate annual costs of

Fixed charges	$ 1,093.35
Fuel	5,044.00
Purchased energy	5,260.12
Total	$11,397.47

and with a unit cost of

$$\frac{\$11,397.47}{408,000} \text{ or } \$0.0279 \text{ per kw-hr.}$$

Summarizing the foregoing, we find the following:

Arrangement	Annual Cost	Unit Cost
With all electric energy purchased and no steam used for generation	$12,511.56	$0.0306 kw-hr.
With full all year generation by means of the 400-kw. engine generating set	$12,213.84	$0.0299 kw-hr.
By installation of a 100-kw. turbine set and the purchase of all power in excess of that capable of being generated with required steam	$11,446.54	$0.0280 kw-hr.
By installation of a 125-kw. turbine set and the purchase of all power in excess of that capable being generated with required steam	$11,397.47	$0.0279 kw-hr.

How these costs may be expected to vary from month to month throughout the year is illustrated by the curves.

Thus it is evident that by the purchase of a 125-kw. unit, generating only an amount of electric energy consistent with exhaust requirements it is possible in a case such as that just cited to secure favorable, if not minimum, costs.

Editor's Note: This is the second of a series of articles on this subject by Mr. Henschel. A third, discussing savings in a furniture factory will appear in a subsequent issue.

IN THE RESEARCH LABORATORY of the General Electric Co. at Schenectady, they have taken a bit of gas only one-eighth the volume of the head of an ordinary pin—and weighing a hundredth of a millionth of an ounce; have put it through a special heating, evacuating and analytical system; and have announced that the speck of gas contained 43 per cent carbon monoxide and 57 per cent nitrogen. How such a small quantity of gas was analyzed, was explained in a paper presented by Drs. F. J. Norton and A. L. Marshall of the General Electric Laboratory at the New York City meeting of the American Institute of Mining and Metallurgical Engineers on February 16.

Troubles occur if metal parts used in the manufacture of vacuum tubes—Thyratrons, radio, photoelectric, pliotron, and various other members of the family—are not thoroughly degassed. Metals such as molybdenum must be heated to a high temperature in a high degree of vacuum in order to expel all of the gas.

Experiments conducted showed that the gas is present throughout the thickness of the metal, and is not simply clinging to the surface. Tests made with molybdenum obtained from numerous commercial sources showed no differences in the nature of the gases present, the amounts, or ease of removal. It was found that the molybdenum parts should be heated at 1760 deg. C. (3200 deg. F.), in a vacuum of the order of a tenth of a billionth of atmospheric presure, for a time depending upon the thickness of the metal, to produce a condition in which gas is no longer given off by the sample.

Having been so treated, the piece of metal can be handled in the air—provided it is kept clean, not touched with the fingers, and is handled with forceps. Then, when the part has been built into a device, it can be degassed readily, for any gas now present is simply a monomolecular layer on the surface.

Inadequate Ground Connection Causes Peculiar Trouble

By V. E. Johnson

INADEQUATE CONNECTIONS to conduit systems constitute at times real hazards to life and property. The following example of an actual case illustrates this very clearly.

An outside electrician was called to a flour mill to investigate a complaint that the running of the main motor caused a sill cock used for sprinkling purposes to get so hot that the garden hose could not be attached.

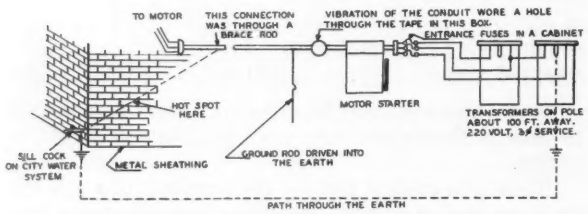

TO MOTOR
THIS CONNECTION WAS THROUGH A BRACE ROD
VIBRATION OF THE CONDUIT WORE A HOLE THROUGH THE TAPE IN THIS BOX.
ENTRANCE FUSES IN A CABINET
HOT SPOT HERE
MOTOR STARTER
TRANSFORMERS ON POLE ABOUT 100 FT. AWAY. 220 VOLT, 3Ø SERVICE.
SILL COCK ON CITY WATER SYSTEM
METAL SHEATHING
GROUND ROD DRIVEN INTO THE EARTH
PATH THROUGH THE EARTH

DIAGRAM SHOWING PATH OF CURRENT TO GROUND

Impossible as the report seemed to be it was nevertheless found to be true.

The connections were in part as shown in the sketch. The motor was fed from an auto-starter supplied from a main panel (shown schematically in the diagram) through a long run of conduit. The service was from a bank of transformers across the street some 100 ft. away, connected in open delta, and with the middle point of one unit grounded at the pole.

In the mill the conduit system, instead of being grounded at the entrance, was connected to earth by means of a driven ground consisting of a half inch rod in the bottom of the elevator pit which happened to be without a floor. This was about 30 ft. from the main fuses.

Examination showed that one of the phase wires had become grounded in a junction box, due perhaps to careless taping or vibration and that a circuit existed from this ground fault through some brace rods to the metal sheathing on the outside of the building and from this to the sill cock and city water system.

The current that flowed was sufficient to heat the sill cock, but not enough to blow the heavy entrance fuses, nor trip the relays on the auto-starter. As a matter of fact, it turned out that the heating of the sill cock was after all a fortunate symptom, for it developed that each time the motor was in operation a certain spot on the imitation brick sheathing became red hot. A fire would certainly have resulted but for the fact that the nails at that point had pulled away so that there was no intimate contact between the wood and metal.

In this case the ground connection was in itself inadequate and was in addition improperly located. A driven rod, such as this was, is an entirely unsatisfactory device for this kind of service. Under the best conditions such a rod will have a ground resistance of at least 5 ohms and this is far too high for real protection. If it is utterly impossible to obtain a water pipe ground, several ground rods should be installed—spaced some distance apart and connected in parallel.

The inadequacy of a 5-ohm ground is evident from the fact that 220 v. will pass only 44 amp. through it (assuming that the return ground has zero resistance) which is not sufficient to blow the line fuse in most industrial installations.

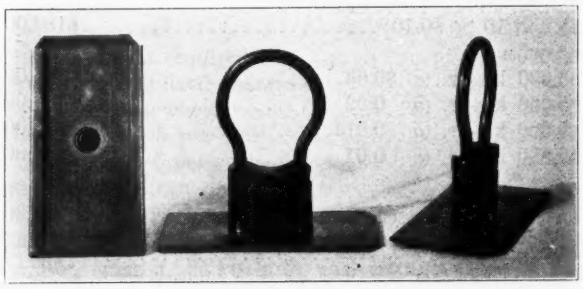
Safety Lock for Line and Substation Switches

By Vernon W. Palen

SOMETIME AGO the writer came across the safety lock described and shown herewith. The device seemed so simple and practical that it was photographed, and is presented here for what it may be worth to other electric companies who may care to use it.

As will be noted from the picture, the padlock is a standard Yale product, with a brass plate soldered across the butt end. A hole in the plate allows the key to be used in the usual way, except when a red warning ticket is present to cover the key opening.

Three edges of the plate are bent into a "U" shape so as to form a pocket for the card. Since, when the card is inserted, the key opening is covered, no one can



SAFETY LOCK FOR LINE AND SUBSTATION SWITCH

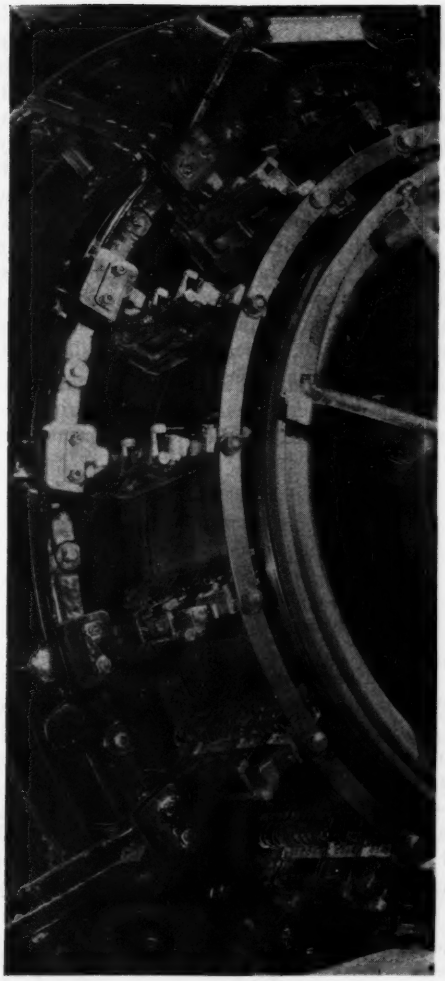
manipulate the switch without wilfully removing the warning card which forbids that very thing. Likewise, it is impossible for anyone to unlock the padlock without having his attention drawn to the warning on the card.

It has been the practice of the company utilizing the device to insert the card only at such times as the line is dead for repairs. Obviously, at such a time it affords valuable protection to the linemen, who might be electrocuted through someone, unaware of the danger, closing the switch.

Cost of attaching the plate to the lock is insignificant and the arrangement has been found especially adapted for use on outdoor line and substation switching mechanisms.

Ordinary relays which protect electrical distribution systems from overload have behavior curves which are hyperbolical; variations in heavy currents make less difference in time of operation than the same variations at smaller current. New schemes of distribution by 4000-v. network, with breakers at each feed-in point, require selective relay action even on quite small current differences—which means a relay whose time of action is inversely proportional to current; whose behavior curve is a straight line. Such relays have been produced and tested successfully.

Commutation Considered As a Switching Phenomenon



COMMUTATION ALWAYS has been a source of difficulty in the operation of direct current machines. While developments in the design of direct current machinery have overcome many of the former difficulties resulting from poor commutation, it still remains a problem that has not been solved entirely. Because of this, it will be of interest here to consider a paper on this subject which was presented at the recent winter meeting of the American Institute of Electrical Engineers in New York, by R. H. Hellmund and L. R. Ludwig, the former chief electrical engineer of the Westinghouse Electric and Mfg. Co., and the latter a research engineer of the same company. This paper considers commutation as a switching phenomenon and while it is of greatest value perhaps to designers, it is none the less of interest to an operator of d.c. equipment.

The usual commutation theories deal with the reversal of the current in the commutating coil and with means for bringing about such reversal either along a straight line or a curve. The principal object of such studies is to accomplish commutation without excessive current densities under the brush. Frequently, of course, it is impossible to realize this, but little attention has been paid to the fact that unless such ideal conditions are obtained we actually have to do with a switching phenomenon and that the problem should be analyzed with this in mind.

Assume that the circuit of armature coil 1 in Fig. 1 is about to be short-circuited by brush B and that at this moment a voltage e is induced in the coil by its rotation in the commutating field, or possibly by the stator field of an a.c. machine. It is evident that sparking in the minute point or edge of the brush B which first touches the segment a will be largely influenced by

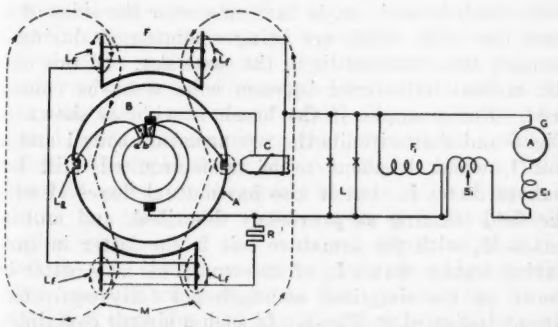


FIG. 1. DIAGRAM SHOWING MOTOR CIRCUIT TOGETHER WITH MAGNETIC FIELDS ASSOCIATED WITH IT

the speed with which the circulating current in the coil can build up as compared with the rate of increase of the area common to the brush and the segment a. This in turn means that the speed of the commutator will have an influence as well as the rate of increase of the circulating current. The latter is determined by the voltage e and the self-inductance and resistance of the circuit of coil 1, if the coil carries no flux common to other closed circuits. This condition would exist if brush B does not short-circuit any other armature coil and if the field winding F is open-circuited, and under the further assumption that there are no secondary damping currents in the stator structure. Under these conditions, the entire main flux F and the leakage fluxes L_a cause a rather high self-inductance in the armature coil 1, and consequently a slow building up of the circulating current. Figure 2 represents a circuit equivalent to the armature coil 1 with the assumptions made so far.

Conditions change materially if the shunt winding F is connected across the armature circuit as shown in Fig. 1, as well as across certain load circuits L and various circuits of the generator G. We now have within the armature coil a leakage reactance flux L_a and a mutual inductance M between the armature coil and the field circuit. The latter in turn has a leakage flux L_f, and it is closed partly through the armature circuit having resistance and inductance and partly through

several other circuits also having a resistance or inductance, or both; in other words, we have equivalent circuits somewhat as illustrated in Fig. 3. The rate of change in the circulating current will now depend upon all these factors, consequently any change of constants in the field circuit or any of the other circuits may have a certain influence upon the commutating conditions. Similarly, any damping currents which can be induced in the solid portion of the stator yoke, or in coil shield or damper windings surrounding the poles, may have an influence upon commutation. The various resistances and reactances shown in the secondary circuit of Fig. 3 are replaced by a single inductance X_2 and a single resistance R_2 in Fig. 4, which while not fully equivalent to Fig. 1 somewhat simplifies the problem.

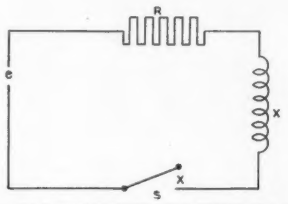


FIG. 2. EQUIVALENT CIRCUIT OF FIG. 1

All the various constants previously mentioned will also have an influence when the circuit of the coil 1 is opened while a circulating current is still flowing in it. There will be one difference, however, in that the high leakage and self-inductances, which are helpful in the case of closing the circuit, will be harmful in the opening because they considerably increase the energy to be dissipated in the spark which forms at the trailing edge of the brush. Mutual inductance, which aids in opening

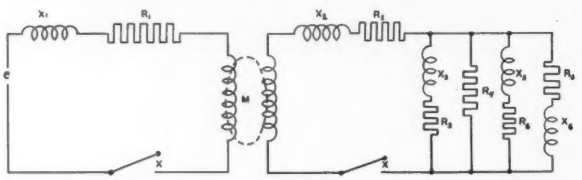


FIG. 3. EQUIVALENT CIRCUIT OF MOTOR CIRCUIT HAVING SHUNT FIELD CONNECTED ACROSS ARMATURE

the circuit as will be explained, is disadvantageous when it is closed because it allows a rapid building up of current. The effect of inductance on the opening operation may be made clear by following the switching operation in detail first for a machine with open stator circuits, wound with one coil per slot, and a brush spanning one commutator bar, so that no account need be taken of mutual inductance between a commutating coil and any other closed winding. A circulating current is assumed to be flowing when coil 1 passes from under the brush.

When a circuit containing resistance and self-inductance such as shown in Fig. 2 is opened by the separation of contacts (the brush and the bar in this case), an arc or spark will be formed between the electrodes, because at the last point of contact the temperature may become very high and "explosions" take place at this point, giving rise to sufficient energy density to establish the cathode spot of an arc on the negative electrode.[1] As the contacts separate further the arc becomes longer and finally becomes unstable and vanishes. Any calculation of the decrease to zero of the circulating current due to commutator bars passing from under the brush must consider this short arc or spark formed. The arc characteristic, i.e., the arc voltage as a function of the current through it, depends on the arc length. The latter in turn is varying and depends on the way in which the arc is lengthened as a function of time, or, in other words, on the speed of the commutator.

If the transient arc characteristic is accurately known for a particular condition, the energy dissipated in the arc can be calculated.[2] This energy may be divided into two parts; the energy stored electromagnetically in the circuit, and the energy supplied to the circuit during the time duration of the arc. In the case of the commutating coil, the latter energy may be supplied by the voltage induced in the coil by its rotation in the commutating field, or in an a.c. machine it can also be induced by transformer action between the stator field and the coil. Usually the total arc energy will lie between the

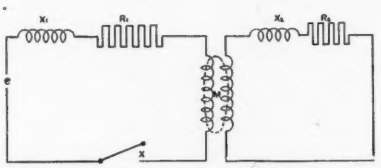


FIG. 4. CIRCUIT IN WHICH THE VARIOUS RESISTANCES AND REACTANCES OF FIG. 3 ARE REPLACED BY A SINGLE INDUCTANCE AND RESISTANCE

values of once and twice the energy stored in the magnetic circuit. This stored energy varies directly with the self-inductance coefficient L and the square of the curent to be broken, and hence the arc energy also depends upon these factors. The length of time during which the arc or spark is present also increases with an increased coefficient of self-inductance. Since a trailing edge spark is harmful in so far as it burns the commutator and brushes, it is desirable to keep the energy to be dissipated in the spark as low as possible. This can be done by lowering the self-inductance, reducing the curent to be interrupted, and also by the proper utilization of mutual inductance.

As previously indicated, circuits having mutual inductance with a commutating coil are established by the field or stator circuit being closed through the armature and other circuits, or by damping currents in the stator structure. Other circuits having mutual inductance with the commutating coils usually exist if the winding is chorded, if there is more than one coil per slot, or if a wide brush is used; or, in fact, whenever the sides of at least two coils which are being commutated during a common time interval lie in the same slot. In this case the mutual inductance between coils must be considered. For example, if the brush is wide as shown in Fig. 5 and short-circuits the two armature coils 1 and 2, coil 1, which is about to be open-circuited, still has leakage fluxes L_1, but it also has mutual fluxes M with the field winding as previously described, and mutual fluxes M_a with the armature coil 2, the latter in turn having leakage fluxes L_2 of its own. This may better be shown by the simplified although not fully equivalent circuit indicated in Fig. 6. If such a circuit containing

1. Slepian, Temperature of a Contact, Jour. of A.I.E.E., 1926, p. 930.

2. Rudenberg, "Elektrische Schaltvorgange," p. 188. (Julius Springer, 1923.)

mutual inductance in addition to self-inductance and resistance is opened with a switch, the decrease of the current in the primamry circuit may again be calculated if the transient arc characteristic curve is known. It is found that in this case all of the stored energy need not be dissipated in the switch. The decrease of current in the primary circuit will induce voltages in the secondary circuits such as to cause their currents to change. This means that part of the energy stored in the primary circuit may be transferred to the secondary circuits and dissipated as I^2R loss in them or held in storage in the secondary circuits. Consequently, the energy dissipated in the spark may be, and usually is, reduced by introducing mutual inductions. The magnitude of the reduction depends on the degree of mutual coupling between the circuits, and upon the circuit constants, such as resistance and self-inductance, of all the circuits having mutual inductance with the commutating coil. It follows, therefore, that as conditions in the stator circuits change, the commutating condition may also change, although such factors as load current, speed, and commutating fields, which are usually considered as the only ones determining the commutating conditions, remain unchanged. For similar reasons, different conditions of mutual inductance between the various armature coils will have an appreciable influence. The conditions of the mutual flux M_a and leakage fluxes L_1 and L_2 in Fig. 6 will of course be appreciably different when the coils are located in separate slots and when the coils are located in the same slot. This difference leads to the frequently observed condition that certain commutator segments show more burning than

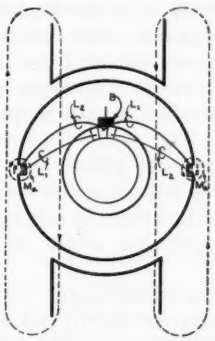


FIG. 5. CIRCUIT IN WHICH THE BRUSH SHORT-CIRUITS TWO ARMATURE COILS

others. These considerations also explain why frequently a split-throw of the armature coils improves commutation as a result of its effect upon the relation between leakage and mutual inductances of the coils. Without the split-throw a good transfer of energy from coil to coil in the same slot may take place, but the last coil in the slot is not well coupled to the first coil in the next slot and hence considerable energy must be dissipated when the circuit of the last coil in a slot is broken. The split-throw reduces this maximum dissipation of energy in the spark because at least one coil side of the coil under commutation is always closely coupled with another coil side, and, assuming that the brush is wide enough to short-circuit the adjacent coil, better transfer of energy can take place. The beneficial effect thus obtained consists not only in decreasing the maximum sparking but also in bringing about more uniform sparking on the different commutator bars, which in turn reduces irregular wear and differences in the heating of the bars; irregular heating of the bars if occurring to any marked extent is likely to cause differences in expansion of the bars and therefore mechanical irregularities in the commutator surface, with consequent further accumulative harmful effects on commutation.

Having established the new concept of switching and the fact that the various machine and external circuits may have an influence upon commutation, we have found a means for explaining many other practical experiences which cannot be explained by the conventional commutation theories. It can be readily seen, for instance, that there may be a difference in commutation between shunt, series, or separately excited machines, between laminated or solid field structures, etc., although the speed, current, and commutating field are the same.

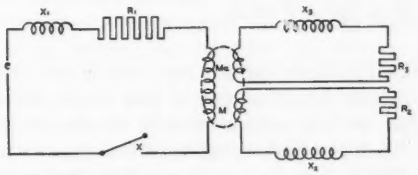


FIG. 6. PARTIALLY EQUIVALENT CIRCUIT OF FIG. 5

It follows that in the case of a.c. commutator machines the commutation may be affected by the size and type of transformer to which the machine is connected and by various other factors. Interesting results may be obtained with two series-connected motors on a motor car, especially in a.c. motors having no damping effects in their field structure. With such machines as phase-advancers or regulating machines connected into the secondary of induction motors, the switching theory readily explains differences in commutation which have been observed by the authors for different connections of such machines to various external circuits.

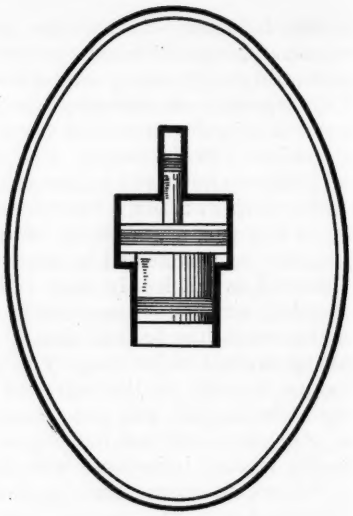
A NEW TYPE OF fuse developed recently in the laboratories of the Westinghouse Co. has shown remarkable performance on test. In the past, when it was necessary to break thousands of amperes at thousands of volts, fuses have been rather spectacular affairs, shooting out eight feet of flame and sometimes bursting.

Hitherto this violence had been attributed to the formation of gas, and engineers had wrought materials which under the heat of the arc would evolve no vapor. Dr. Slepian proved that it was this very vapor evolutions which extinguished the arc, and contended that the cure for the trouble was some material which would yield maximum volumes of non-explosive vapor. This was found in a most unexpected substance, solid boric acid, which yields water vapor when heated.

From this starting point, Strom and Rawlins developed a fuse which breaks 20,000 amp. at 13,200 v. without arousing any excitement. In the center of a thick walled cylinder of boric acid is a plunger, which would be withdrawn deep into its hole by a spring were it not held forward by the fuse wire which serves as one terminal. When the fuse melts, the arc is drawn into the boric acid hole, and elicits an outrush of water vapor which instantly extinguishes it. This boric acid fuse is usually a disappointment to spectators who are often unable to detect any sign that it has operated.

POWER PLANT ENGINEERING March 15 1932

DIESEL ENGINE UPKEEP



PART XX. METHODS OF AVOIDING TROUBLES WITH AIR COMPRESSORS. VALVE MAINTENANCE. DETECTION OF VALVE LEAKAGE.

BY EDWARD J. KUNZE

AIR COMPRESSORS are used on Diesel engines to supply air for admission of fuel in the air injection system and for pre-compression of air in the two-cycle system. To make fuel spraying effective, the air must be about 400 lb. higher in pressure than that compressed in the power cylinders. To permit operation within reasonable temperatures, employment of three stage compression with intervening intercoolers is required.

By this means, the high-pressure discharge temperature is reduced to 250 deg. F. instead of being at least 1500 deg. which would be the case if no intercoolers and no aftercoolers were used. The practical advantages of stage cooling are: reduced danger of cylinder fracture, freedom from explosions of lubricating oil which may have collected in the discharge piping and better service from the compressor valves due to operation under lower temperature range. The high pressure, 900 to 1000 lb., under which air compressors of this type operate necessitates exercise of special care.

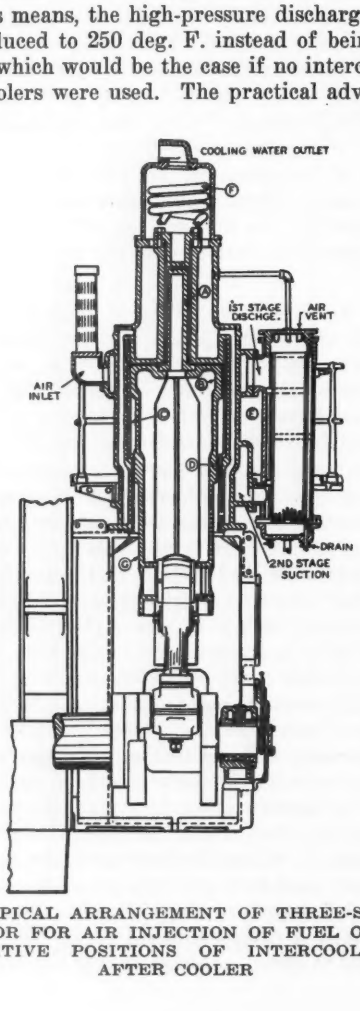


FIG. 1. TYPICAL ARRANGEMENT OF THREE-STAGE AIR COMPRESSOR FOR AIR INJECTION OF FUEL OIL, SHOWING RELATIVE POSITIONS OF INTERCOOLERS AND AFTER COOLER

DIFFERENTIAL PISTON CONSTRUCTION

By use of a differential piston, shown in Fig. 1, the space above B forms the low-pressure cylinder in which the air is compressed to about 60 lb., then after passing through intercooler E it is recompressed to about 250 lb. in the annular space C, from which it passes through intercooler G and receives its third compression stage in cylinder A, whence it discharges through an aftercooler consisting of a submerged copper coil F, into the air line.

Because of the small piston clearances, great care must be exercised in adjusting the crank and piston pin bearings, as a slight change in clearance, especially in the high pressure cylinder, affects the compressor performance.

As bearings wear down, piston clearances should be checked. The clearance usually allowed is from 1/32 to 1/16 in. on the low and high stages and from 1/8 to 3/16 in. on the intermediate stage. Care should be taken especially to keep the clearance properly divided between the two ends.

VALVES MUST BE KEPT TIGHT

Due to the high pressure involved, the compressor valves must be kept tight, move easily in their guides and have proper lift. Because plate or disc valves are light and need no lubrication, they are most popular for this purpose. Plate valves or disc valves must be guided. Although springs increase their efficiency they frequently are omitted to avoid spring troubles due to the heat under which they operate. In this case, it is necessary to limit the rise by adding a suitable stop to the valve cage. A popular type of disc valve is illustrated in Fig. 2 and a modification of the disc type, which is of helical flat coil construction, is illustrated in Fig. 3.

Most valves are in cages which can be removed and replaced quickly. It is wise, therefore, to have a few

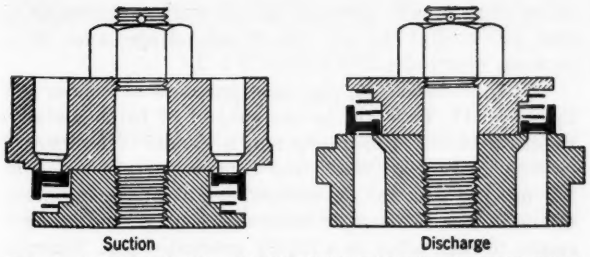


FIG. 2. SUCTION AND DISCHARGE VALVES OF THE DISC TYPE

sets of valves with cages as a supply, thus permitting overhaul of the valve and cage removed from the engine, at any convenient time later. Low-pressure suction valves are likely to be found dirty if the air has not been filtered. Discharge valves will be clean unless too much lubrication has caused them to be carbonized.

Valves and cages best may be scraped by blunt and comparatively soft tools to avoid marring their surfaces. Following the scraping, the parts should be washed in kerosene or gasoline and dried in a blast of air. Flat valves and seats best are ground on a surface plate. If the plate is not in good condition, it is well to finish grinding them together. The grinding should be done evenly over the entire surface of the plate. If the valve is worn badly, time will be saved by facing it with a file before the grinding operation. It is much better to repair the valves before they have become badly worn. It is not necessary to use an abrasive each time but the valves should be given at least two or three turns in place to be sure they are seating properly.

When replacing the valves, care should be exercised to return them as they were originally. Since the pressure is from below on the suction valve cages, care must be taken to see that these cages are fastened securely. Gaskets should not be removed when valves are taken out unless they have been destroyed but if they are disturbed, they should be taken out and annealed, if they are of copper, or renewed, if they are of asbestos with copper reinforcement.

Prevention of Slamming and Breaking

Excessive valve lift, which causes slamming and sometimes results in breakage, should be guarded against; the heavier the valve the more the lift must be restricted. Wear of valves or seats increases lift; this may be compensated by facing off the cage.

If a sharp click can be heard when the valves seat or if they show signs of battering when removed, the lift should be restricted. Attachment of an indicator to the compressor, when such provision has been made, is the best way to discover whether the lift is too restricted or passages are choked with carbon. Slamming may be caused also by pulsations set up in the delivery pipe if the receiver is placed at considerable distance from the engine. For this reason, the receiver should be close to the compressor or, where that is not feasible, the introduction of a well-drained, large section of pipe close to the compressor will reduce the intensity of pulsations set up from this cause.

Most serious of all troubles that may occur in an air injection system, aside from the remote possibility of explosion, is loss of spray air. Falling off of spray pressure, if the compressor suction is open and the bleeder valve on the first stage adjusted properly, may be due to leaky, broken or stuck valves, a spray air valve sticking open, leaky spray air valve steam packing, leaky joints in the spray air piping or failure of the cooling water supply. If the engine is permitted to operate when the spray pressure has dropped too close to compression pressure in the power cylinder, there is a possibility of an explosion inside of the spray valve body.

Valve Leakage

Valve leakage is one of the most troublesome features of compressor operation; for this reason, it is important to have an independent source of supply such as an auxiliary motor-driven compressor available in the plant for such an emergency. The surest indication of compressor trouble is falling off in capacity and a good indication of the location of the trouble is shown by the pressure gages attached to the various stages. Any variation from the normal relative pressures is usually an indication of a leaky valve. If leakage occurs in the low-pressure valves, the pressure will fall on all three gages. If the suction valve leaks, air may be heard or felt blowing back and a rise in temperature will take place, while a leaky discharge valve will be indicated by rise in pressure in that stage due to blowing back from the intermediate stage.

Trouble with the intermediate-pressure valves is indicated by fall of pressure in that stage and increase in pressure in the low-pressure stage. A leaky intermediate discharge valve results in rise in pressure in that stage. Piston ring leakage in either cylinder also will cause a rise in pressure in the cylinder directly below it except in differential piston construction, in which case leakage of the upper sets of rings causes a rise in pressure in the low-pressure stage due to air blowing back from the high-pressure stage and leakage of the middle set of rings will cause, likewise, a rise in pressure in the low-pressure stage due to air leakage from the intermediate stage. Leakage through the lower set of rings causes the intermediate stage air to blow into the crankcase.

Leakage of either of the high pressure valves will cause the intermediate pressure to rise. If it is the discharge valve that leaks during the suction stroke, the cylinder will receive some of its air from this source instead of receiving its entire charge from the lower

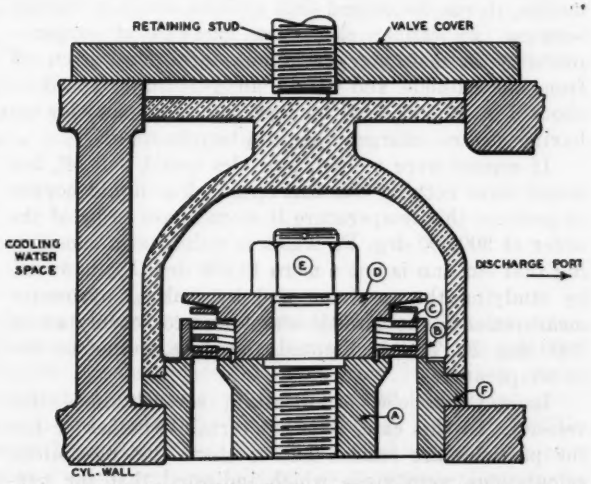


FIG. 3. AIR COMPRESSOR VALVES OF HELICAL FLAT COIL CONSTRUCTION

stage. If the suction valve leaks, air will pass back into the cooler during the compression stroke. A simple test for leakage of the high pressure discharge valve is to turn air from the spray air bottles into the line when the engine is stopped and open the indicator cocks on the high pressure cylinder. Leakage will be indicated by emission of air through the cocks.

Leaking valves heat up but the temperature of the discharge valve and piping always is so high that change in temperature is difficult to detect unless pyrometers are attached. If the cooler is some distance from the compressor, the pipe connecting it with the suction valve will serve as a guide as leakage will increase the temperature of this pipe. If this pipe is inaccessible, the valve cover may aid in detection. A convenient check on these temperatures may be had, where pyrometers are used for exhaust temperatures, by connecting them with thermocouples placed in the compressor discharge area.

A Fast One for the Scientist

RESEARCH LABORATORIES are interesting places. Every once in a while something happens which is seemingly inexplicable and then a discussion starts. The following comes to us from the Research Laboratory of the Westinghouse Electric and Manufacturing Co. and is reprinted from the Electric Journal for August. It has to do with fast moving particles of copper.

"Where do these particles of copper get that speed of 125 mi. per sec.? That is what puzzles us," Mr. Mason stated as he leaned against his laboratory table loaded with curiously shaped glass containers, vacuum pump tubing, and wires. I peered into a glass bell jar which seemed to be the center of interest, but except for a couple of electrodes placed at right angles to each other and an insulated silver vane in front of one of them, I could see nothing very exciting.

"Oh, no. You can't see very much, nevertheless there is a most interesting phenomenon," Mason explained and then proceeded to tell a story of an experiment conducted by Mr. Berkey and himself, which is interesting if only because it is a good example of research men's experiences.

During the course of an investigation of another matter, it was discovered that with an arc in a vacuum between two copper electrodes, particles of copper—probably in molecular or atomic form—are given off from the cathode and attain an astounding speed of about 2×10^6 cm. (125 mi.) per sec. For particles not having electric charges, this is a terrific speed.

If copper were molten, particles would boil off, but would have nothing like this speed. For liquid copper to produce this temperature it would have to be of the order of 900,000 deg. F., which is quite warm considering that our sun is but a mere 10,000 deg. F.; however, by studying the spectrum and by making pyrometer measurements, the cathode was found to be only about 3000 deg. F. This high speed, therefore, cannot be due to temperature.

Ionized particles often attain several times this velocity. In this case, it is not certain whether or not the particles are ionized but to check this possibility, calculations were made which indicated that for particles to attain such a velocity through electrical gravitation they would have to fall through a potential of over 100 v. But the arc was of low voltage, some 20 v. between electrodes.

Whence, therefore, do these particles of copper get their speed? This will be the subject of further study. Practical value when finally run to earth? Who knows?

The manner in which the copper particle speed of 125 mi. per sec. was determined is an interesting story in itself. The two copper electrodes were placed at right angles to each other in a highly evacuated jar. Directly in front of the cathode, but out of the arc stream, was suspended an insulated metal vane whose weight had been accurately measured. When the arc had been formed, the vane swung away from the cathode a few millimeters. This swing was also carefully measured. Then knowing the weight of the vane, it was a simple matter to calculate the force necessary to move the vane as a pendulum through this distance. The vane was reweighed, giving the mass of copper deposited on it. These values substituted in the equation, force $\times$ mass = velocity, gave a simple means of calculating the velocity of the particles striking the vane.

MEASURING THE SPEED OF MOLTEN COPPER PARTICLES

To provide a check on these results, the experiment was repeated in which the energy delivered by the particles to the vane was determined. The vane was again carefully weighed before and after the experiment to give the amount of copper striking it, and the rise in temperature of the vane was measured by a thermocouple. Knowing the mass of copper striking the vane, the particle velocity was determined from the relationship, Energy $\times$ $\frac{1}{2}$ M V^2 and was found to be in close agreement with the previously determined figure, 2×10^6 cm. per sec.

HUMAN BEINGS can do four times as much work in a temperature of 100 deg. when the relative humidity is 30 per cent as when it is 100 per cent and can perform at maximum efficiency only between the temperature limits of 40 and 75 deg. F., according to facts quoted in a report recently issued by the Policyholders Service Bureau of the Metropolitan Life Insurance Co. Humidity and air motion as well as temperature must be considered if conditions most favorable to health and efficiency are to be maintained. "The control of air temperature," the report states, "without reference to its moisture content or rate of movement, was at first believed to be the best method of providing comfortable conditions. This belief still persists to some extent, although ample evidence is available indicating the influence of both the dry and wet bulb temperature, as well as the rate of air movement."

BURNS FROM hot metal particles flying from an electric arc should be dressed immediately, as they may form dangerous sores difficult to heal.

Steam Flow Chart for Low Pressures

By Julius Hulman

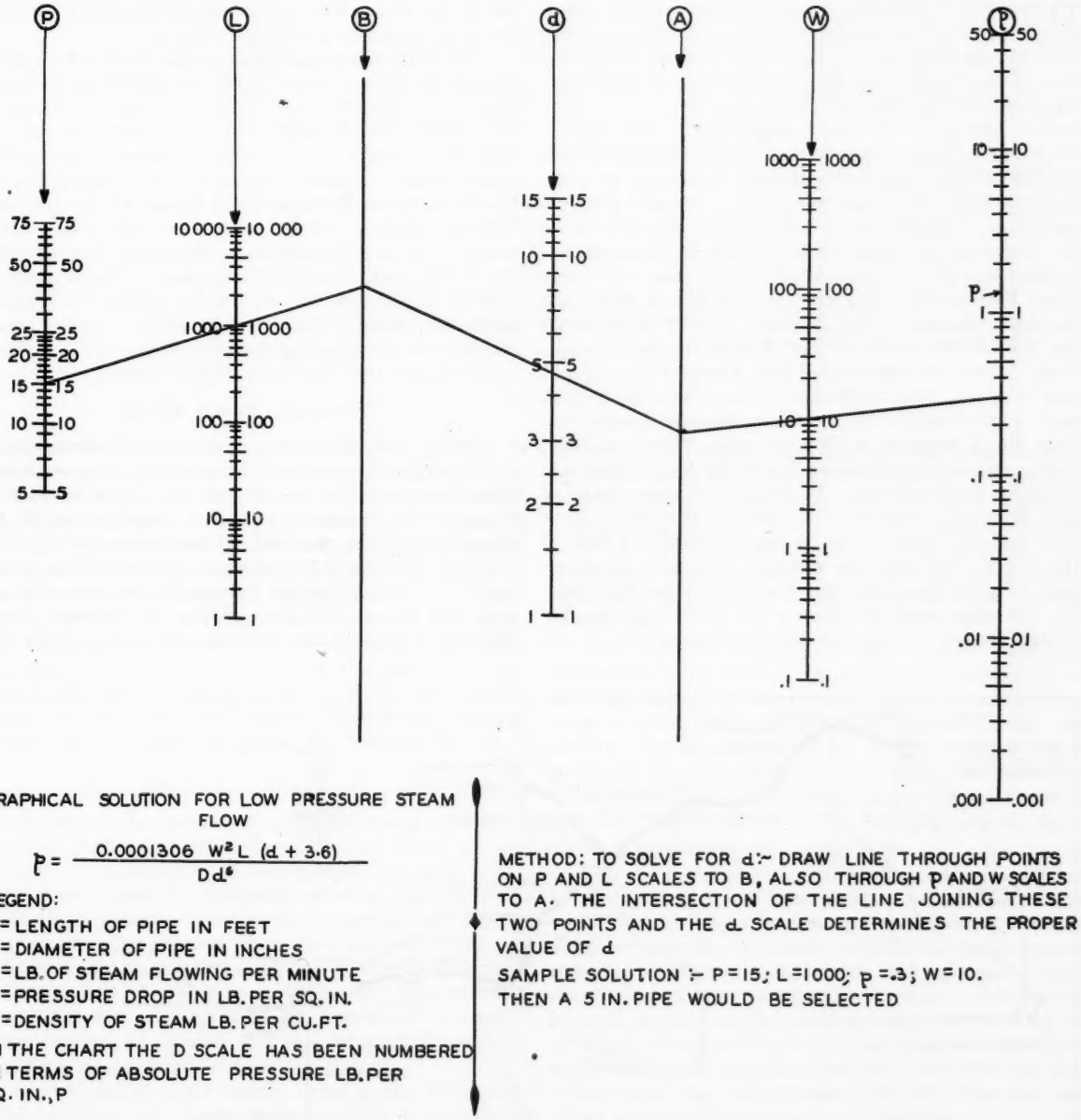
FOR DETERMINING pressure drop and steam flow, the equation shown on the chart is used, combined with Babcock's friction coefficient, $f = 0.0027\ (1 + 3.6 \div d)$. The chart, which uses logarithmic scales, gives an accurate solution for any variable when the other four are known, use being shown by the illustrative example.

Pipe diameters shown are actual internal diameters and should be related to nominal pipe sizes by use of a piping table. The nearest commercial size for best economy should be chosen and pressure drop determined for it.

For values of W greater than shown, take 1/10 the actual value, determine the pressure drop on that basis and multiply by 100 to get actual drop.

For high pressures and large diameters, the equation and chart are inadequate and more complicated equations are necessary.

Of all the facts regarding daylight, the most striking one is its intensity. Sunlight, on a clear day produces an intensity of 6000 to 10,000 ft.-candles. Imagine, if possible, a printed page lighted, not by one but by 10,000 candles placed 1 foot from it. When such intensities are even approached in artificial lighting such as in the immediate neighborhood of a giant 30,000 watt lamp, the effect is simply scorching and the observer soon removes himself to a cooler place at a respectful distance.



GRAPHICAL SOLUTION FOR LOW PRESSURE STEAM FLOW

$$p = \frac{0.0001306\ W^2 L\ (d + 3.6)}{D d^6}$$

LEGEND:
L = LENGTH OF PIPE IN FEET
d = DIAMETER OF PIPE IN INCHES
W = LB. OF STEAM FLOWING PER MINUTE
p = PRESSURE DROP IN LB. PER SQ. IN.
D = DENSITY OF STEAM LB. PER CU. FT.
IN THE CHART THE D SCALE HAS BEEN NUMBERED IN TERMS OF ABSOLUTE PRESSURE LB. PER SQ. IN., P

METHOD: TO SOLVE FOR d:- DRAW LINE THROUGH POINTS ON P AND L SCALES TO B, ALSO THROUGH p AND W SCALES TO A. THE INTERSECTION OF THE LINE JOINING THESE TWO POINTS AND THE d SCALE DETERMINES THE PROPER VALUE OF d

SAMPLE SOLUTION :- P = 15; L = 1000; p = .3; W = 10. THEN A 5 IN. PIPE WOULD BE SELECTED

POWER PLANT ENGINEERING March 15 1932

Prospect Diversion Project with 7200-Kw. Hydroelectric Plant

EXTENSIVE SYSTEM OF DAMS, CANALS, FLUMES AND PIPE LINES MAKES 350 SEC-FT. ADDITIONAL FLOW AVAILABLE AT PROSPECT NO. 2 AND DEVELOPS 7200-KW. AT PROSPECT NO. 3, ON ROGUE RIVER IN OREGON

PROSPECT diversion project, construction of which is expected to be completed about June 1, is being built by the California-Oregon Power Co. to utilize the flow of the South Fork and Middle Fork of the Rogue River also of Red Blanket Creek, by diverting this flow to the forebay of Prospect plant No. 2, thus adding some 350 sec-ft. of water to that already available from the North Fork and, in the process, developing an additional 7200 kw. at a new completely automatic generating plant, Prospect No. 3, built on the South Fork of the Rogue River. Detailed description of Prospect No. 2 plant was given in the April 1, 1928 issue, of Power Plant Engineering. The general plan, Fig. 1, shows the physical relation of the diversion project to Prospect No. 2 while the curves of Fig. 4 show the water conditions. It will be remembered that Prospect No. 2 plant now contains two 23,400-hp. water wheel generating units while Prospect No. 1, a short distance downstream from No. 2, contains a 7000-hp. unit. When the third unit is installed at Prospect No. 2, the No. 1 plant will probably be abandoned. On Fig. 4 the lower curve of flow duration represents the flow of the North Fork only and the upper curve shows the combined flow of the North Fork and the complete diversion as represented by the past nineteen years of stream flow data. On this same chart is shown a line indicating the discharge capacity of the turbines in Prospect No. 1 and No. 2 and also a line indicating the discharge capacity for three turbines in Prospect No. 2.

This diversion project consists essentially of a system containing three diversion dams, the largest on the South Fork of the Rogue River, the next on the Middle Fork, the third on Red Blanket Creek; an interconnected system of wood stave pipe lines, open, concrete-lined canals and wood stave flumes to collect the water and deliver it finally to the small storage pond formed by the diversion dam at Prospect No. 2; a hydroelectric power house utilizes for power production the water flowing from the South Fork diversion dam, where it drops approximately 700 ft. to the wood-stave siphon that passes across the Middle Fork to the canal; a 73-kv. transmission line for carrying power to Prospect No. 2 where it is fed into the California-Oregon system.

AUTOMATIC POWER HOUSE

One of the important features of this development is the completely automatic Prospect No. 3 power house, placed in operation by closing the circuit-breaker at Prospect No. 2 power house that connects it with the transmission line, provided all conditions are right for starting. The No. 3 power house, shown in Fig. 2, contains a 10,000-hp. vertical Francis Pelton hydraulic turbine driving a 7200-kw., 6900-v., 0.8 power factor, 60-cycle, 3-phase Allis-Chalmers generator at 720 r.p.m.

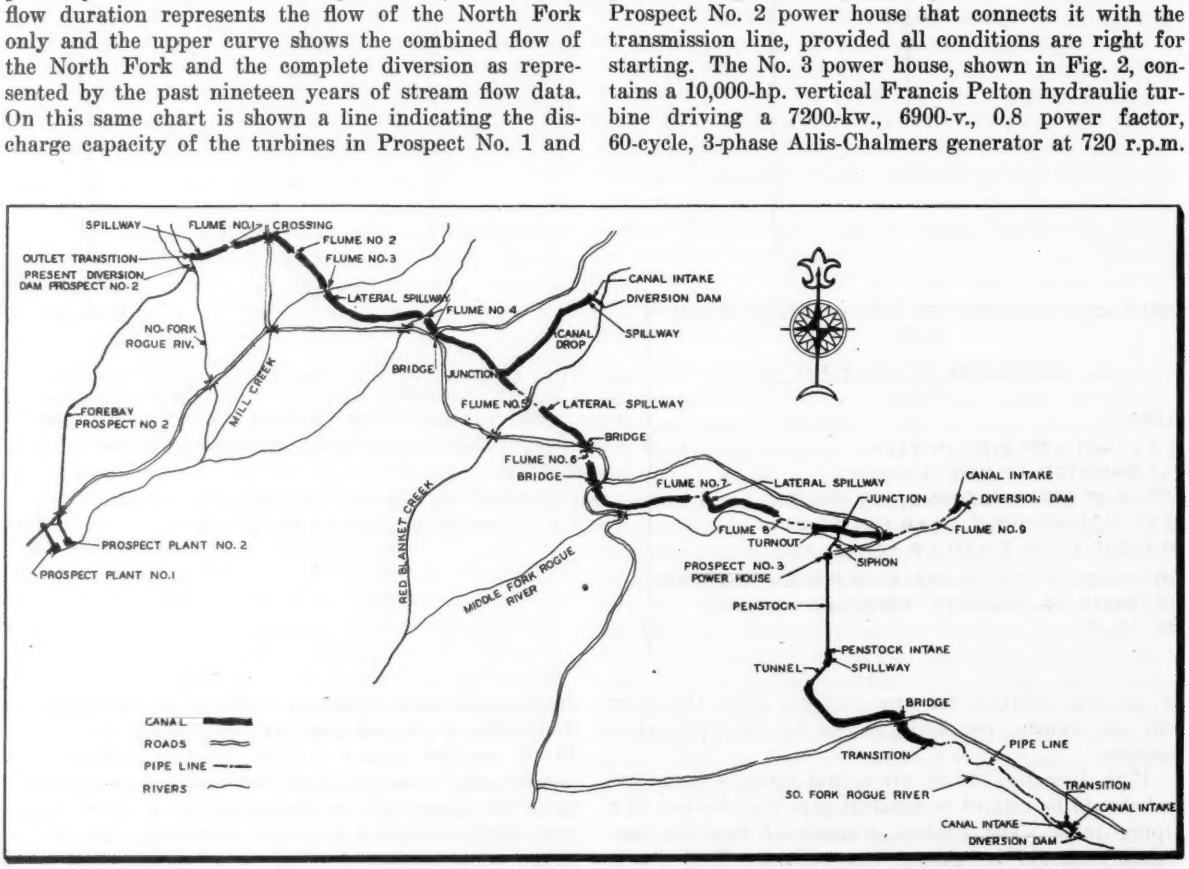
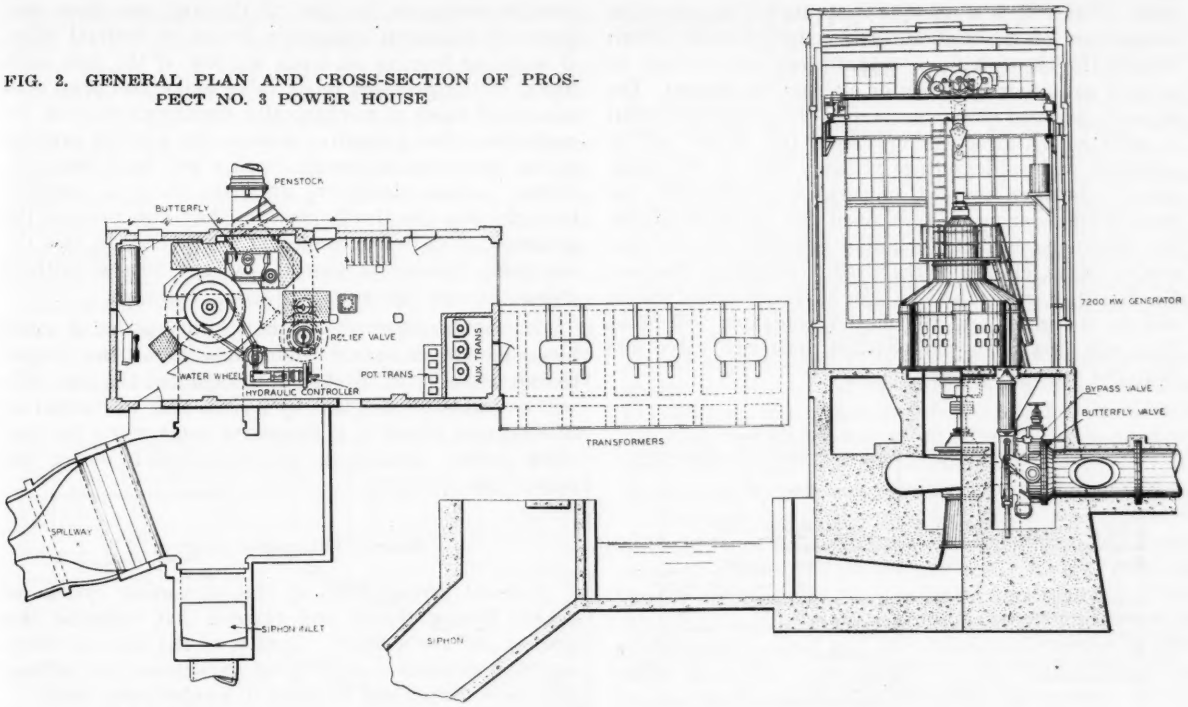


FIG. 1. GENERAL MAP SHOWING SCOPE OF PROSPECT DIVERSION PROJECT, INCLUDING DIVERSION DAMS, POWER HOUSE NO. 3, CANALS, FLUMES AND PIPELINES

FIG. 2. GENERAL PLAN AND CROSS-SECTION OF PROSPECT NO. 3 POWER HOUSE



This turbine operates under a net head of 693 ft. It operates under the control of a hydraulic controller, the latter actuated by Selsyn motors from a float control in a small concrete chamber just ahead of the penstock intake. When the unit is in operation, the float control governs it with a total operating range of 1 ft. variation in water level between full open and full closed gate on the turbine. If the water level rises above normal, the excess flow will pass over the spillway with which the penstock intake is equipped. In this case, the water wheel will take the normal flow but if the unit is shut down, the water can be bypassed through the pressure relief valve through the siphon to Prospect No. 2.

Methods of Operation

Details of the method of operation are given below. As Fig. 2 shows, a butterfly valve just ahead of the turbine admits water from the penstock, this valve being opened and closed by hydraulic pressure, applied automatically when the plant is being started and before any of the other starting operations can occur. At the inlet end of the penstock, another butterfly valve controls the flow of water to the penstock; this valve is closed automatically by a weight and trigger arrangement in case of trouble and can be opened only by pumping oil by hand to raise the weight.

Just ahead of the butterfly valve at the lower end of the penstock is a bypass connection, Fig. 2, containing a pressure relief valve interconnected with the controller in such a way that when the turbine gates are moved quickly towards the closed position the relief valve is opened sufficiently to discharge the water rejected by the turbine and thus prevent undue pressure rise in the penstock. After being opened by the controller, the relief valve is closed slowly by a dashpot arrangement. If the turbine is shut down the pressure relief valve will be used as a bypass valve to discharge the water into the siphon. In this case the controller will be disconnected from the relief valve and the valve will be set in the open position by hand. In order to prevent starting the turbine when the relief valve is disconnected, an electric switch is so arranged that when the connecting rod is removed the switch automatically opens and the turbine cannot be started until the rod is replaced.

The hydraulic controller that adjusts the gate mechanism is shown in Fig. 2. Vertical movement of the float control at the penstock intake is transmitted from a Selsyn motor to a Selsyn receiver on the controller. The receiver actuates control switches which make the proper connections to drive the controller motor in one direction or the other and the motor drives a jackscrew that moves in one direction, a differential piston actuating the gate mechanism.

The opposite side of the differential piston is subject at all times to wheel case pressure which keeps it in contact with the jackscrew and causes the piston to move towards the open gate position as the jackscrew retreats. In case of a shutdown, from any cause other than a drop of water level in the forebay, a deënergized solenoid permits the hydraulic opening of a valve on the controller which admits wheel case pressure to the jackscrew end of the operating cylinder and since this side of the piston has a larger area than the other side, the piston is moved to the closed-gate position.

When the wheel gates have been closed for a shutdown a deënergized solenoid permits the butterfly and butterfly bypass valves to close in sequence. After these valves are closed, air is admitted.

Electrical Circuits

When the unit at No. 3 is completely shut down, the electrical circuits of the station are dead if the circuit breaker in the transmission line at Prospect No. 2 is

open. Figure 3 is a one-line diagram of the electrical connections of the station. The hand-operated circuit breaker in the auxiliary transformer circuit can be tripped out either by direct or alternating current. The solenoid-operated circuit breaker in the generator circuit is actuated by direct-current from the exciter and is equipped with undervoltage release. Now, if the hand-operated breaker is closed, sufficient water available, the water-wheel bearing oil tank filled and all other operating conditions correct, including resetting of any protective relays, closing of the circuit breaker at Prospect No. 2 will energize the line, the auxiliary transformers will be energized and the master contactor will close. This will first open the penstock butterfly valve and then the turbine gates.

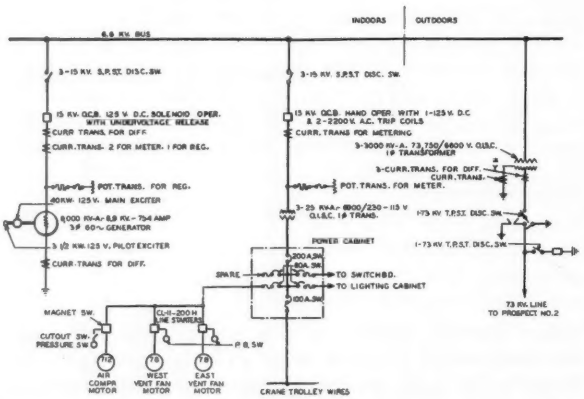

INDOORS
OUTDOORS
6.9 KV. BUS
3-15 KV. S.P.ST. DISC. SW.
15 KV. O.C.B. 125 V. D.C. SOLENOID OPER. WITH UNDERVOLTAGE RELEASE
CURR. TRANS. FOR DIFF.
CURR. TRANS. 2 FOR METER, 1 FOR REG.
POT. TRANS. FOR REG.
60 KW. 125 V. MAIN EXCITER
8000 KV-A. 8.9 KV. - 754 AMP 3 Ø 60 ~ GENERATOR
3 1/2 KW. 125 V. PILOT EXCITER
CURR. TRANS FOR DIFF.
15 KV. O.C.B. HAND OPER. WITH 1-125 V. D.C. & 2-2200 V. A.C. TRIP COILS
CURR. TRANS FOR METERING
3-3000 KV-A. 73,750/6600 V. O.I.S.C. 1Ø TRANSFORMER
3-CURR. TRANS. FOR DIFF.
CURR. TRANS.
POT. TRANS. FOR METER.
3-25 KVA- 6900/230 - 115 V. O.I.S.C. 1Ø TRANS.
POWER CABINET
200 A. SW.
60 A. SW.
SPARE
TO SWITCHBD.
TO LIGHTING CABINET
100 A. SW.
MAGNET SW.
CUTOUT SW.
PRESSURE SW.
CU-II-200 H.P. STARTERS
P.B. SW.
AIR COMPR. MOTOR
WEST VENT FAN MOTOR
EAST VENT FAN MOTOR
CRANE TROLLEY WIRES
73 KV. T.P.S.T. DISC. SW.
1-73 KV. T.P.S.T. DISC. SW.
73 KV. LINE TO PROSPECT NO. 2

FIG. 3. SINGLE-LINE DIAGRAM OF ELECTRICAL CONNECTIONS. PROSPECT NO. 3 POWER HOUSE

When the unit has reached about 98 per cent synchronous speed, the solenoid-operated generator circuit breaker, for which power is now available from the generator exciter, closes automatically and connects the generator to the line. Excitation is then applied to the generator field and the machine pulls into step. Closing of the main generator breaker causes the load control to be transferred to the forebay level control mechanism, allowing the turbine gates to open to the limit established by the forebay float, permitting the generator to operate at the load corresponding to the available water.

Normal shutdown may be effected by opening the circuit breaker at Prospect No. 2. A shutdown may also be effected by the operation of any one of the protective relays. These relays will open the master contactor, which will in turn de-energize the hydraulic controller mechanism, close the turbine gates and open the relief valve, then close the butterfly valve. At the extreme closed position of the turbine gates or the butterfly valve, the main oil circuit breaker will open and the other shutdown operations, including braking, will proceed in normal sequence.

Protective equipment includes devices to shut down the generating unit temporarily in case of overheating, overspeed, electrical unbalance, low bearing oil and several other difficulties. The machine will stop and lock out in case of generator trouble, hot bearing, failure of excitation, high line voltage, unbalance during starting, low water level, or trouble in the hydraulic controller. The machine is prevented from starting if the a.c. line is not energized, if single or reversed phase rotation exists on the line, if the unit has been shut down by a lockout protective device or thermal relay, if water or bearing oil levels are low, if the gate valve ahead of the penstock relief valve is not full open or if the relief valve is mechanically disconnected from the controller. The protective devices also prevent opening of the generator oil circuit breaker and field contactor, during normal shutdown, until the gates or penstock butterfly are practically closed. They also prevent the generator from being connected to the line, in case the generator breaker is opened, for any reason, without going through the normal starting sequence.

No regular operator will be on duty at No. 3 power house but an attendant will always be on the project to look after gates, ditches, spillways and the like. He will be called to the plant by a siren that will sound an intermittent alarm if a protective relay shuts the machine down. Indicators will show which device has caused the shutdown.

Water Diversion System

General arrangement of the interesting system of canals, flumes, piping and tunnels that comprise this project are given below. Details of the various water-carrying structures are of great importance and interest and these details will be given in a subsequent issue.

Diversion dam on the South Fork is a concrete gravity type weir about 30 ft. high above the foundations and 158 ft. long. At the right-hand end of this dam, looking downstream, a concrete canal intake leads the water into a fish screen chamber, then into an open concrete-lined spillway section 72 ft. long and then into a wood-stave pipeline 66 in. in diameter. In the fish-screen chamber, a paddle wheel rotated by the flowing water will drive a rotary screen, to prevent fish going downstream, while provision is made in the dam itself for a fish ladder to enable fish to pass up or downstream. On top of lateral spillways section, vertical pieces of pipe 1 ft. long are placed at intervals so that the height of the spillway can be adjusted to suit operating conditions. If necessary, the spillway top can be grouted to whatever additional height is demanded by the water flow conditions.

The wood stave pipe line runs about 5400 ft. from the end of the spillway section, then, by suitable transition section to reduce friction losses, it joins an open concrete-lined canal, which carries the water to the penstock intake just above the power house, as shown in Fig. 1. Just before the canal reaches the penstock intake, it is converted into a concrete-lined tunnel section about 700 ft. long, to pass through a ridge directly to the intake. This intake, which is a long section of open concrete-lined channel with a lateral spillway on one side of it, furnishes a small amount of forebay capacity for the No. 3 power house, to which the water is led from the intake by a 72 to 48-in. dia. steel plate penstock. Water discharges from the power house into an open basin, Fig. 2, from one side of which a wood-stave pipe siphon carries it across the Middle Fork to the canal on the opposite bank. A spillway outlet will carry the water to the Middle Fork in case it is desired to unwater the siphon.

On the farther bank of the Middle Fork, the siphon empties into the open concrete-lined canal leading from

the Middle Fork Diversion Dam upstream, Fig. 1. This dam is a low gravity type concrete weir similar in design to the South Fork Dam, with the canal intake and fish ladder at the right hand end. This intake has a spillway section and fish screens and connects with a wood-stave flume supported on wood trestles. This flume runs about 2200 ft. and then connects as shown with the open canal section. In this canal, just downstream from its junction with the siphon, a lateral spillway is placed on the canal that discharges into the natural channel of the Middle Fork. Here also is a turnout, controlled by a Tainter gate through which the entire flow of water at this point can be diverted back to the stream bed in case work is to be done on the canals downstream. The The canal continues from the turnout, in the manner

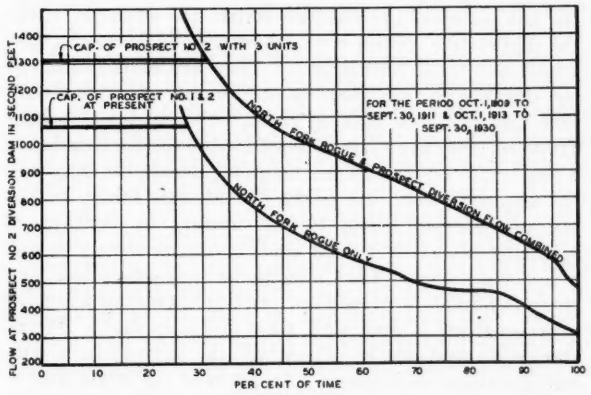

CAP. OF PROSPECT NO. 2 WITH 3 UNITS
CAP. OF PROSPECT NO. 1 & 2 AT PRESENT
FOR THE PERIOD OCT. 1, 1909 TO SEPT. 30, 1911 & OCT. 1, 1913 TO SEPT. 30, 1930
NORTH FORK ROGUE & PROSPECT DIVERSION FLOW COMBINED
NORTH FORK ROGUE ONLY
FLOW AT PROSPECT NO. 2 DIVERSION DAM IN SECOND FEET
PER CENT OF TIME

FIG. 4. FLOW DURATION CURVES, NORTH FORK ROGUE RIVER AT PROSPECT NO. 2 DIVERSION DAM

shown in Fig. 1, and consists of various sections of open canal and wood stave flumes. From the Red Blanket Creek dam, a structure consisting of a low concrete spillway section and an earth embankment, with canal intake and lateral spillway of the same design as at the other dams, an unlined open canal runs to join the Middle Fork canal near flume No. 5, then the canal continues as shown, emptying into the pond above Prospect No. 2 diversion dam.

This project was designed for The California-Oregon Power Co. by Byllesby Engineering & Management Corp. of Chicago under the direction of H. W. Fuller, vice president in charge of engineering and construction, and F. H. Lane, manager of engineering and construction. J. Wm. Link, hydraulic engineer, and H. W. Eales, chief electrical engineer, were in charge of the design, the details being worked out by Stephen Wehner, assistant hydraulic engineer, and H. L. Hoeppner, electrical engineer. The construction was under the direction of Geo. F. Phythian, superintendent of construction.

NEW ORDERS for electrical goods booked during the fourth quarter of 1931, as reported to the Bureau of Census by 84 manufacturers, were $151,586,124, as compared with $157,303,909 for the third quarter of 1931 and $208,935,443 for the fourth quarter of 1930. These bookings include motors, storage batteries, domestic appliances and industrial equipment and are presented not as a complete statement of the industry but as an indication of the trend.

Record Installation of Mercury-Arc Rectifiers

LARGEST installation of mercury-arc rectifiers in this country and probably in the world is being made beneath the streets of New York City to supply direct-current power for the operation of the new Eighth Avenue subway in the boroughs of Manhattan, Queens, Bronx and Brooklyn. The initial unit of this new subway is expected to be started in operation in the near future and the portion of the project now contracted for and under construction will include more than 200 track-miles in the four boroughs.

For supplying third-rail power in this new subway system a total of 51 mercury-arc rectifiers, totaling 153,000 kw., are either under construction or already installed, and 53,000 kw. of synchronous converters are ready for operation in five surface substations. All are of General Electric manufacture.

The location of the rectifiers below street level is unique. Underground rooms, constructed of reënforced concrete adjacent to the subway, are located at different depths according to the particular conditions involved. All of the switching equipment is automatic, with remote supervisory control and the distribution of the various units along the right-of-way is such as to minimize as far as possible the necessity for expensive feeder equipment.

Each rectifier will have a nominal rating of 3000 kw. at 625 v. and will carry double load current without injury for 5 min. The units have 12 anodes each, operating in 12-phase relation and are supplied with alternating current from transformers stepping down the 13,500- or 27,000-v., three-phase, 60-cycle supply.

Special provisions for lowering the equipment into the sub-surface station and arrangements for suitable ventilation and cooling water have been made. Since no operators are required, the supervisory apparatus will supply complete information as to the condition of the various units and will enable the supervisor to advise the maintenance staff of any attention that may be required by the various units.

A NEW TYPE of high-speed distance relay for protection against line-to-line faults on short transmission lines has been developed recently. The essential feature of this new relay is that it is essentially unaffected by the presence of accidental fault resistance but does not require the use of an auxiliary element to prevent operation of the relay under load conditions when there is no fault on the system. This relay and its theory of operation was fully described in a paper by Goldsborough and Lewis of the Westinghouse Co. at the recent winter meeting of the A.I.E.E. in New York.

"RESONANT CONTROL" is a simple, reliable and flexible method of remote control for apparatus connected to a power distribution system, including those applications ordinarily requiring pilot wires and time switches and eliminates the need for separate control wires. It operates by means of medium frequency currents, having a frequency around 500 cycles superimposed upon the regular power circuits which operates relays tuned to respond only to the control frequency. The relays operate by direct electromagnetic pull without the use of vacuum tubes, rectifiers or amplifiers of any kind.

Off Duty

In a letter from a reader in far off Chile, he takes exception to certain views which we expressed recently in an Off Duty article[1] in which we questioned the value of "gadgets" in human happiness. Perhaps we did not express our views as clearly as we intended for in criticizing our present day dependence upon gadgets and advocating a more active interest in cultural pleasures we were not necessarily condemning our machine or industrial civilization as our critic inferred. If in this article, by implication we criticized the machine, it was not the machine itself that we had in mind but our unintelligent application of it in the world today. While we still agree with Dr. Mees in his contentions that the inhabitants of the average American city are perhaps little if any happier than were those of the Greek or Babylonian cities of the past, we do not believe that they could not be happier (with our machines) if our machines were more intelligently applied. The mere fact that science and engineering, save in checking disease, have been of little value in adding to the happiness of mankind, does not imply that they cannot and will not do so.

Indeed, we would be the last to place the blame for the world's present day troubles on the machine. We believe that the machine is inherently capable of adding to the welfare, the happiness and the comfort of humanity. If it has not done so, it is not the fault of the machine but of man's own inability to adjust himself and his institutions to the infinitely great productiveness of the machine. Already, it has lifted many burdens from man's shoulders—this we pointed out in our previous article and if in the civilized countries of the world, it has not leveled out the extremes between poverty and riches, at least, it has done much to level out the extremes of absolutely unbridled indulgence in human desires practiced by the old potentates and the abject misery of those less fortunate.

The thought that we intended to convey was not that the machine, "the gadgets", were at fault but that we would do well not to make them our sole concern in life. The automobile is a marvelous machine, bringing ease, leisure and pleasure to large masses of the population but its use involves the danger that it may become the sole concern of those who use it, not merely a means to an end which fundamentally it is. Our criticism of the automobile concerns its use by people merely as a means of escape from themselves—from boredom, as they also use bridge and golf. Rushing madly through the country they are so absorbed in going to and coming from "nowhere" that they have no time or inclination for the beauties of the hills or mountains through which they pass. It never occurs to them to park their machine somewhere and spend a few idle hours tramping through the woods or over the hills or along the seashore in the quiet contemplations of nature's beauties.

Critics of the machine have discoursed at length upon the dehumanizing influence of the automatic machine upon those who tend it—of its stunting effect upon both mind and body. And then by way of comparison they paint for us the picture of the old-fashioned craftsman, who with a few simple tools and the work of his own hands and muscles fashioned things which were a source of joy to his heart and inspiration to his soul.

But how much of this joy and untrammeled freedom of the old handworker exists in the imagination of those who paint these rosy pictures? Here, understand, we are not considering the creative artist for art is in a class by itself, but rather the worker who labored to keep the wolf away from his door. True, if his labor was of a kind that involved skill, we do not deny that he may have taken a degree of selfish pride in his accomplishments, but in most cases it is possible also that the monotony of repeated efforts and the constant strain of accomplishing enough even in the long hours which constituted his day, to earn a bare existence, greatly dampened his enthusiasm.

If anybody doubts this, let him go to some of our non-industrialized countries and watch the handworker in action there. Warren S. Thompson discusses this at length in the current issue of the American Mercury. He has watched the Chinese smith, for example, make the diminutive sickles with which rice is harvested and which sell for a cent apiece. They are neither artistic nor durable nor can there be any reason why one should take any pride in making them. Yet, to make a bare existence, the smith has to work twelve to fourteen hours a day, or if he doesn't his neighbor across the way will get ahead of him. At night, for all this labor, he has the privilege of going to bed hungry or perhaps of spending his ten or fifteen cents a day on some rice and a few vegetables. True enough he is his own boss and there is no one to drive him. But let him stop work for ever so short a time and what does he find? Want, starvation and death! These are the drivers in a non-industrialized civilization. And it is so the world over—in China, India, central Asia, Africa and in America.

As pointed out by Mr. Thompson, in a handwork civilization the dreary, harsh and almost bestial nature of much of man's work is difficult for most of us to conceive. Fuel is packed on the back or pushed in a wheelbarrow; water is carried the same way; stevedoring is done on the back—food is scarce and the diet is exceedingly monotonous. In most cases the food is what one would consider fit only for cattle and poultry. These are only a few items out of innumerable others that we might mention but they will serve to indicate what we mean. Indeed, handwork is so unproductive that as long as it persists 95 per cent or more of the people must live on a bare subsistence level, in squalor, cursed with all manner of disease, suffering from cold and hunger and leading a most wretched existence.

With machines, properly applied and managed intelligently for the benefit of the human race, the work of the world could be done in from 5 to 8 yr. That is, a man or woman finishing school or college at the age of say 21 or 22 could do all the work necessary in the five or eight years following and then at the age of 30 or thereabouts could retire on full pay for life! With the machine utilized properly there is absolutely no reason why human beings should be compelled to toil their entire lives as they do today, merely to earn a living.

And so in criticizing our industrial civilization as it exists today we do so only from the standpoint of unintelligent management. The fact that we find the machine a problem today is not a reflection on the machine itself but upon the sheer inability of financiers, politicians, statesmen, lawyers and so-called executives to keep pace with the developments of the scientist and engineer.

1. September 15, 1931.

Readers' Conference

What Price Neglect?

SOME MONTHS ago, the writer attended a convention of engineers and before returning home, made a few side trips for the purpose of inspecting a number of industrial power plants as well as several ice and cold storage plants.

For most part, the plants visited were found to be well maintained and efficiently operated. Likewise, the engineers in charge were wide awake, progressive and efficient. A brief description of a few exceptions to this, however, both as regards the plants and the engineers may be of interest.

In one plant the generator and exciter of an 800-kw. Diesel electric unit that had been in service about 2 yr. were observed to be thoroughly saturated in oil. In fact, oil was actually dripping from the stator windings of both the generator and exciter, while the rotors were in about the same condition.

Looking around in this engine room, it was not difficult to discover the cause of the oil saturated machinery. A lubricating oil purifying machine of the mechanical type was used for continuous oil cleaning and was so located with reference to the generator that the oil vapors were carried by the prevailing draft directly to the generator end of the unit where the revolving flywheel and rotor completed the job of pulling the oil laden air into the windings.

The oil purifier could easily have been located elsewhere or provided with a vapor outlet that would have removed the oil vapors from the engine room entirely. The cost of either method of correcting the trouble would have been slight, certainly not over ten dollars.

Ultimately, the damage to this unit because of oil soaked windings will be many times greater than that of the cost of corrective measures.

In another plant, two natural gas engines supplied the power requirements. Both engines had been in service several years and had proved most economical both in fuel and maintenance costs and in fact no interruption to service had been experienced since these engines were placed in operation. They had, however, received no attention but on the other hand had been very much neglected. The general appearance of the plant as a whole was the worst that I have ever seen and the personal accident hazard was unquestionably of the greatest.

Any attempt to oil line shaft bearings with the plant in operation was to court disaster. Two of the three horizontal air compressors driven by belts from the main shafting were absolutely inaccessible while the engines were operating which, for several months of the year, were required to operate 24 hr. a day.

Careful examination of this installation disclosed a few other defects as follows: Engine exhaust pipe reduced in diameter one-half inch less than the exhaust outlet at the engine, a condition made worse by an unusually long exhaust line from one of the units.

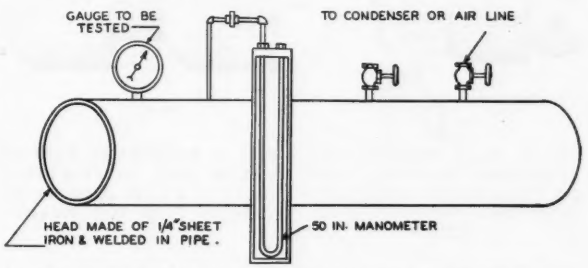
Engine jacket water supply inadequate because of defective and improperly erected piping system. Absence of air filters on the air supply to the engines, the necessity of which was evident from the dirt laden air in the immediate vicinity of the plant.

Oil soaked floors, machinery and belting resulting in a bad fire risk. The engineer in charge of this plant stated that he did not believe in engineering publications and engineering societies and therefore made no use of either. The condition of the property loudly proclaimed this fact.

Atlanta, Ga. C. T. BAKER.

Calibrating Vacuum Gages

THERE ARE many low-pressure and vacuum gages around power plants on pump suction and discharge lines, heater and extraction lines and similar equipment. At times it is desirable that the accuracy of these gages be known. At our plant, and I imagine most other plants, the low-pressure gages were tested as well as possible on a dead weight tester and the vacuum gages were set at zero and condenser vacuum. With these methods, the dead weight tester did not give good results at less than 20 lb. per sq. in. and we did not know how accurate the vacuum gages were between the two points at which they were set.



CONSTRUCTION AND ARRANGEMENT OF TESTING EQUIPMENT

To overcome these difficulties, a device was made up as follows: A cylinder was made by welding ends cut from ¼-in. sheet steel onto about an 18-in. length of 6-in. pipe. Four ¼-in. nipples were then welded into top of the pipe. To one of these nipples is attached a manometer or for testing vacuum gages a mercury column vacuum gage may be used for this. Needle valves are placed on two of the nipples and the gage to be checked is attached to the remaining nipple.

The device is used as follows: If a vacuum gage is to be tested, a ¼-in. line is run from the condenser to one of the needle valves on the apparatus. Then with the other needle valve closed the pressure may be lowered in the cylinder in any desired steps by slightly opening the needle valve to the condenser. When the desired vacuum is obtained as shown by the manometer, the valve is closed tight. After full condenser vacuum is attained in the cylinder with the valve to the condenser shut off, the vacuum may be lowered by a similar manipulation of the needle valve to the atmosphere. This will give a set of readings up and then down the scale.

A similar procedure is followed for checking low pressure gages except that instead of attaching the device to a vacuum line it is attached to a source of air or gas pressure and the manometer readings must be converted from inches of mercury to pounds per square inch.

This device has proved invaluable for checking low pressure and vacuum gages at our plant and I believe it can be used by others to an advantage.

Victoria, Texas. JOHN P. WHITE.

Pump Repairs

As I glance over a list of repairs just completed on a pair of centrifugal boiler feed pumps, it carries me back to 25 yr. ago when centrifugals were not so common and problems seemed to be more complex.

One double walking beam pump of quite some capacity serving a big jet condenser, never worked satisfactorily from its day of christening until it was twenty

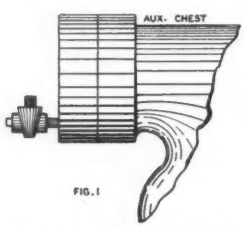


FIG. 1. COCK INSERTED IN AUXILIARY PISTON CHEST TO RELIEVE EXCESS PRESSURE AND IMPROVE OPERATION

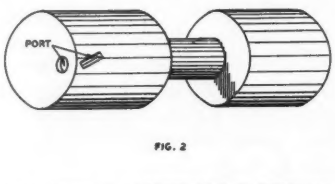


FIG. 2. AUXILIARY PISTON VALVE FOR ACTUATING MAIN VALVE AND PORT WHICH WAS TOO SMALL

years old. Then a cock (Fig. 1) was placed on each end of the auxiliary piston chest head to relieve the excess pressure caused by too small an auxiliary exhaust port (Fig. 2) and more or less piston ring leakage. The cock was only cracked open enough to allow the piston free travel. This pump was cured of a lingering sickness in about 2 hr.

Again a large locomotive air compressor that I remember had a habit of stopping to rest just when most needed. It was not on a locomotive but in a power house and was used to furnish air for tube drilling and scaling. One of the firemen was an old locomotive fireman and he used railroad methods. When the pump stopped, he would hit the auxiliary chest with anything from a twelve-inch monkey wrench to a four-pound hammer.

The same method was used on this pump until a cock was placed on the end of the auxiliary piston chest where steam was admitted. Just a slight leakage of this cock allowed the pump to work perfectly.

Lawrence, Mass. TOM THUMB.

Mold in Cold Storage Rooms

IT IS IMPORTANT to hold any product in cold storage at an even temperature and at the same time maintain the proper humidity to avoid unnecessary shrinkage. Mold is usually found where there is dampness and dampness is the cause of it in storage rooms. The usual cause of dampness is from allowing the air in the room to become warmer than the product so that moisture in the air that has leaked in through doors and openings without being properly chilled condenses when it strikes the colder surfaces.

Where air is allowed to enter or even where the room is large and large spaces are left between the coils and the farthest product, it is well to use one or more fans to keep air in circulation and keep an even temperature. Eggs absorb mold readily and even though it is not visible, the taste is there. So it is with fruits and vegetables. A pitcher of ice water in a warm room sweats, due to condensation of moisture from the air. So it is with products in cold storage and once the moisture hits this product, it is almost certain to form mold.

Kansas City, Kan. J. F. STALEY.

Bomb Calorimeter Determinations

IN TESTS for the heating value of coal made with the Emerson bomb calorimeter outfit, we have had great difficulty in obtaining values for the same coal which would check within the required limits of the A.S.T.M. test code. While supervising tests made by students in the Mechanical Engineering Laboratory at North Carolina State College for the past ten years and while making tests himself, the author has persistently tried to overcome errors and variations due to student carelessness or personal differences in manipulation.

It seemed to the author that check runs on the same coal should give heating values with an error of not more than one-half of one per cent, if carefully carried through; that is, for coals having heating values of 13,000 to 14,000 B.t.u. per lb., successive runs should check within 50 to 70 B.t.u. Most of the time this was not the case, in fact it seemed as though we were lucky if we obtained two successive tests which checked within 100 B.t.u. Often the difference ran over 150 B.t.u. per lb., or an error of over one per cent.

In order to eliminate differences and errors, we began systematically to try to get rid of the several variations possible in preparing the coal and starting the test. We first standardized on using 60-mesh coal, as most of the coals tested are bituminous or semi-bituminous. We had been using 100 or 60-mesh coal rather indiscriminately. This helped somewhat but still we had wide variations in heating value.

Then we standardized on using as nearly 10 cm. (2.5 in.) of soft iron fuse wire as possible. Although this is a small item, nevertheless, for comparative runs, it makes an appreciable difference if there is a big variation in the length of wire used.

Next we standardized on using only dried coal. We used the coal from the 4-gram sample which had previously been heated in the electric oven in order to find the per cent moisture in the coal. Then we tried using the water in the bucket (1900 grams) at 2 to 3 deg. C. (4 to 5 deg. F.) below the room temperature so as to obtain approximately the same radiation corrections. This seemed to help decidedly, still we had many wide differences in results.

Even the oxygen came in for suspicion but about all we could do there was to try to standardize on pressure in the bomb; so, to be sure we had enough for complete combustion, we used 450 lb. per sq. in. as the minimum allowable pressure.

At last we began trying to use exactly 1.0000 gram of coal in the pan. This did not take much more time to weigh than to get the exact weight of 1.0693 grams

or some such figure and it also simplified the calculations.

Still the variations occurred without any apparent logical reason. Then one day last winter when we had some coal to test for one of the State Institutions, we found a student tapping the coal pan on the bench because some of the coal was on the edge of the pan and he wanted it all together in the center. The result was that the coal was packed together tightly in the pan and level instead of in a pile or mound as we usually had it. This looked strange to me and made me think that there would be incomplete combustion, as the oxygen would not be able to "get at the coal"; however, we went ahead with the run and found after opening the bomb that we had had complete combustion. There was no carbon deposit at all on the inside of the bomb.

This set us to thinking and experimenting. Two runs in succession gave identical heating values when the coal was packed in the pan. Two runs made in succession on a different coal gave values within 10 B.t.u. When we went back to the old way of loose coal in the pan the variations came again.

So it seems as if we could say at last that we can get check runs on the heating value of the coal if we pack the coal in the pan before the pan is placed in the bomb. It is only necessary to tap the pan a few times upon the bench or table. Also, after placing the pan in the wire holder and arranging the fuse wire so that it touches the coal, the pan may be tapped with a pencil to pack the coal around the fuse wire.

The reason for obtaining better combustion seems to be due to burning the coal from the surface rather than having an explosion which would blow the coal over the inside surface of the bomb.

The author has never heard of this suggestion of using packed coal in the pan before and would greatly appreciate hearing from other experimenters as to their results.

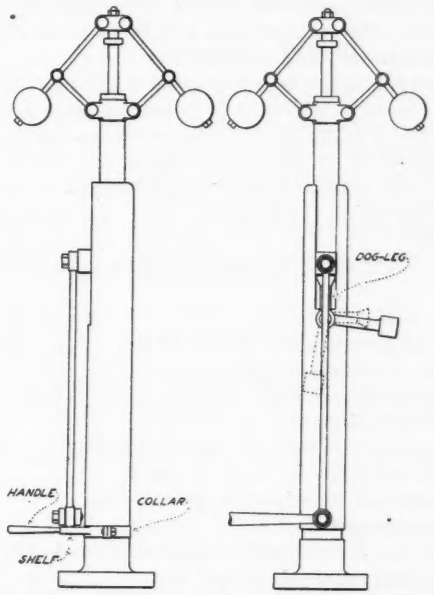
Raleigh, N. C. WM. JAY DANA.

Corliss Governor Supports Were Hazardous

SHOWN AT THE LEFT in the accompanying sketch, is the device provided for holding the governor of a Corliss engine at starting position when the governor was standing idle, a small shelf projecting from a brass collar encircling the governor supporting column. It was presumed that, after starting the engine, the operator would turn the collar and shelf to permit the balls to drop to safety position, in case the governor belt should break and that he would shift it back to catch the descending mechanism when shutting down the engine.

Obviously the element of uncertainty about this device made it objectionable to the insurance underwriters; so they ordered it taken off and a dog-leg attachment substituted, as shown at the right of the sketch. When shutting down, the operator would hold the dog-leg upright until the rectangular stud projecting from the governor sleeve rested upon it. When the stud was lifted by the governor balls rising to the running plane as the engine was started, the dog-leg would swing of its own weight to the position indicated by the dotted lines.

Notwithstanding the automatic feature of this device, the personal element was almost as great a source of danger as before. Two engines in the mill, were located at opposite ends, the smaller of the two being held in reserve. One night a breakdown necessitated starting the reserve engine. The main engine ran with steam at a boiler pressure of 90 lb., but the reserve engine required 110 lb. to do the same work. The engineer ran the smaller engine up to speed with the boiler pressure still at 90 lb. but, when the load was thrown on by closing a friction clutch, the speed diminished until the safety cams stopped the engine completely. In order to keep the machinery going while the fireman was raising the pressure to the necessary 110 lb. the engineer tied the dog-leg in the upright position with a piece of cord, standing by and cutting the cord when the pressure was high enough to keep the governor balls at the normal running plane.



TWO DESIGNS OF UNSAFE STARTING SUPPORTS FOR GOVERNORS

There was no sacrifice of safety in this so far as the engineer was concerned but it proved a mischievous object lesson to the boss of the mill hands, who was watching the proceeding. Previously, he had caused much annoyance by stealing in unobserved and shifting the supporting shelf and collar to the non-running position, thinking thus to keep the engine speeded up and so enable him to get more work out of the machines. The dog-leg attachment held him safe until he saw how easily its automatic feature could be set aside. Anyway, the engineer later on found the dog-leg tied snugly to the governor post with its business end up. His vigilance was timely. In another half hour the wornout lacing of the governor belt broke.

Little dependence can be placed for safety on any provision for leaving the safety cams free to operate when a stop is used during the starting up period. Just as the spring loaded safety valve is the most dependable device for guarding against boiler explosions from overpressure, so the automatic engine stop is the best device for guarding against engine destruction from overspeed.

St. Louis, Mo. D. J. ALTIZER.

Plant Operation Problems

Proper Lighting for Drafting Room

IN FEBRUARY 1, 1932, issue of Power Plant Engineering is a question and answer entitled, "Proper Illumination for Drafting Room," to which I take exception.

Modern lighting standards recommend 25-ft.-candles as good practice and 15 ft.-candles as a minimum. The former figure gives excellent shadowless light for all fine work.

The walls and ceiling shall be considered as finished in light colors producing a good reflecting surface without glare. The window area will be taken as consistent with modern building practice.

From tables for an open indirect lighting unit for a ceiling height of 10 ft. to 13½ ft., we get a suspension distance of 2 ft. to 2½ ft., a depreciation factor of 0.70, a coefficient of utilization of 0.27 and a lumen output of a 75-watt standard lamp of 967 lumens.

For six units, you have—

$$\frac{30 \times 18}{6} = 90 \text{ sq. ft.} = \text{area per outlet to be illuminated.}$$

$$\text{Lumens per lamp} = \frac{\text{Area per outlet} \times \text{Foot-Candles}}{\text{Depreciation factor} \times \text{Coef. of utilization}} =$$

$$\frac{90 \times 15}{0.70 \times 0.27} = 7150 \text{ lumens per lamp.}$$

$$\text{The actual illumination provided} = \frac{\text{Lumens provided}}{\text{Lumens required}} \times \text{desired foot-candles} =$$

$$\frac{967}{7150} \times 15 = 2.2 \text{ ft.-candles—provided by your lighting unit with a 75-watt light in it.}$$

Now going to the recommended practice with the same conditions as above except that the lamp wattage is to be found, we have:

$$\frac{90 \times 25}{0.70 \times 0.27} = 11{,}900 \text{ lumens required.}$$

The nearest lamp rating is for a 500-watt light with a lumen output of 9750 lumens.

$$\frac{9750}{11{,}900} \times 25 = 20.5 \text{ ft.-candles} =$$

actual illumination with 500-watt light.

Considering eight lighting units spaced 7½ ft. by 9 ft., with 3¾ ft. and 4½ ft. respectively between the last unit and the walls, with the same ceiling heights and suspension distances, you have a depreciation factor of 0.70, and a coefficient of utilization of 0.27.

$$\frac{30 \times 18}{8} = 67.5 \text{ sq. ft. area per lighting unit.}$$

$$\text{Lumens of lamp} = \frac{67.5 \times 25}{0.70 \times 0.27} = 8928$$

Again the 500-watt lamp's lumen rating is nearest with 9750 lumens.

$$\frac{9750}{8928} \times 25 = 27.2 \text{ ft.-candles} =$$

actual illumination with eight lighting units (indirect of course) and with 500-watt lamps.

Either of the two lighting solutions offered would give good results. The last solution would give the best results in preventing eye strain and giving shadowless light on the drawing boards.

Springfield, Ohio. D. W. RIFFELL.

Volumetric Efficiency of Pump

A DOUBLE-acting duplex reciprocal pump 14 in. by 8 in. by 12 in. stroke at 50 single strokes per min. on each side with steam pressure at 100 lb. per sq. in. gage takes suction from city supply at 20 lb. and delivers 27 cu. ft. to a height of 330 ft. What is the percentage of slip? What is the mechanical efficiency?

A. V. L.

A. To find the slip, first find the volumetric efficiency. The formula for this is $E = Q_e/Q$

Where Q = plunger displacement

Q_e = actual volume discharge

To find Q, multiply the piston travel in ft. per min. (100) by the area of the plunger in sq. ft. (0.349)

$100 \times 0.349 = 34.9$ cu. ft. per min. displacement.

$E = 27 \div 34.9 = 77.3$ per cent volumetric efficiency.

The slip is 1 — volumetric efficiency, or

$1 - 0.773 = 0.227$ or 22.7 per cent slip.

To find the mechanical efficiency of the pump, follow the formula given here:

$$E_m = \frac{\text{ft-lb. output}}{\text{ft-lb. input}} = \frac{\text{weight of 1 cu. ft. of water} \times \text{c.f.m.} \times \text{head}}{\text{stm. piston area} \times \text{stm. press} \times \text{piston travel f.p.m.}}$$

$$= \frac{62.5 \times 27 \times 330}{154 \times 100 \times 100} = 0.361 = 36.1 \text{ per cent mechanical efficiency.}$$

Furnace Questions and Pipe Expansion

WHAT IS meant by the terms "full arch" and "half arch" setting?

2. Is it possible to use a stoker with a dutch oven furnace?

3. What is the expansion of cast-iron and steel piping? J. O. L.

A. A "full arch" setting is one that practically covers full length of the grate, other than a chain grate, while a "half arch" covers a half or less of this surface.

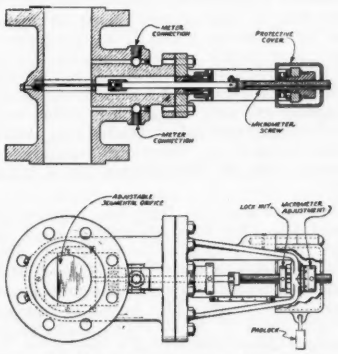
2. Any mechanical stoker may be used in connection with a dutch oven or extension furnace.

3. The linear expansion of pipe in inches per 100 ft. at 100 deg. F. is 0.72 for cast iron and 0.76 for steel. At 200 deg. these values are respectively 1.5 and 1.57 and at 300 deg., 2.35 and 2.47.

New Equipment

Adjustable Flow Meter

To OBTAIN accurate measurements with fluid meters over a wide range of capacity, the Bailey Adjustable Orifice has been designed by the Bailey Meter Co. This is particularly suitable for measuring gas or



BAILEY ADJUSTABLE ORIFICE

low pressure heating steam, since the desired capacity is often dependent upon the season.

This adjustable orifice consists of a flanged body tapped for connection to any differential-head type of fluid meter. A micrometer adjusting screw permits setting the height of the gate segment within 0.001 in. To change the capacity of the meter, set the micrometer screw at the reading corresponding to the desired maximum capacity, as obtained from curved sheets furnished with the orifice.

Change in the maximum capacity of the meter is as much as 40 to 1, which may be made in a few minutes without disrupting meter operation or diverting the flow through a bypass line.

Feed Pressure Regulating System

SMOOTH feedwater regulation in high-pressure plants requires a regulator control which responds accurately to changes in water level, exact control of pressure drop across the regulator valve and automatic bypass of the differential pressure regulator for emergency feed of large volume of water. In the newest S-C equipment of the Swartwout Co., insignificant fluctuations in differential pressure are amplified and used to operate the differential pressure valve.

In the diagram, A is the regulator, operated by control generator B, the drop across A to be maintained constant. To do this, valve C is used, its action being controlled by master valve D.

Steam, water or air pressure at 80 to 250 lb. is introduced at E, passes through valves D and F, the latter normally being inactive, then through pipe G to the diaphragm of C. From inlet and outlet of A, connections are carried to the two sides of the diaphragm of D, so that its position, hence the opening of valve D, is controlled by the pressure differential across A. Should this increase, venting through J is diminished, pressure in G is increased and valve C moves to close, decreasing the pressure at the inlet to valve A. With decrease of pressure differential, this action is reversed. Valve C is thus kept in such position that pressure drop across A is held constant at the lowest value consistent with feeding the boiler under all normal loads, holding A relatively wide open so as to give good regulation.

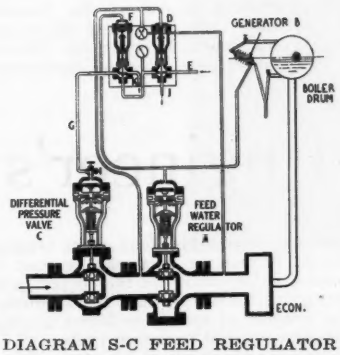


DIAGRAM S-C FEED REGULATOR ACTION

To meet normally high loads, valve F is interposed, its diaphragm being under pressure from generator B, opposed by a spring. For any normal water level, F remains closed with plunger in highest position and free passage of pressure to valve C. If water level falls too low, pressure in generator B is increased, the plunger of valve F moves downward, throttling the pressure from valve D and venting through K. This allows valve C to open, the action being progressive, until C is wide open and full pump pressure is applied to the inlet of valve A, which is also wide open, permitting the flow of the maximum amount of feedwater that the pump can force through the full pipe area opening.

Lamme Medal Awarded to Giuseppe Faccioli

GIUSEPPE FACCIOLI has been awarded the 1931 Lamme Medal of the American Institute of Electrical Engineers. It will be presented to him at the summer convention of the Institute which is to be held in Cleveland, O., June 20-24, 1932.

This medal, founded as a result of a bequest of the late Benjamin G. Lamme, chief engineer of the Westinghouse Electric and Manufacturing Co., is awarded annually to a member of the Institute who has shown meritorious achievement in the development of electrical apparatus. This year, therefore, the medal is bestowed upon Mr. Faccioli for his contributions to the development and standardization of high voltage oil filled bushings, capacitors, lightning arresters and numerous features in high voltage transformers and power transmission.

Death of William T. Walker

WILLIAM T. WALKER, construction superintendent, Northern States Power Co., died suddenly Thursday, February 25 at Grand Forks, North Dakota. Death was caused by uremic poisoning six hours after he had become afflicted.

Mr. Walker was born in Lawrence, Kansas, on June 28, 1874, and graduated from the University of Kansas in 1897. He became associated with the Byllesby organization in March, 1910. During the 22 yr. that followed, he acted as construction superintendent for a number of prominent projects,

News From the Field

QUINCY, Ill., city council recently adopted an ordinance granting the Central Illinois Public Service Co. a 40-yr. franchise for gas and electric utilities in the municipality, dependent upon approval by stockholders of transfer of the headquarters from Springfield, Ill., to that city, enabling Quincy to levy taxes upon the $3,750,000 capital stock of the corporation. E. F. Kelly, vice-president of the utilities corporation, who was in Quincy negotiating for the franchise, expressed his confidence in favorable action by stockholders. A 10-yr. contract, retroactive to Feb. 1, for street lighting was also negotiated, effecting a saving of $200 a week to the city, on the $35,000 annual contract. It was estimated that about $98,000 taxes will be collected by the city and school district under the proposed change.

NORDBERG MANUFACTURING CO., Milwaukee, Wis., announce the following recently elected officers: Robert E. Friend re-elected president; Edwin C. Bayerlein, senior vice-president and treasurer; A. E. Ballin, formerly president of McIntosh & Seymour Corp., vice-president; Geo. W. Lowe, re-elected secretary and James A. Friend, assistant secretary.

AT THE ORGANIZATION meeting of the board of directors of The New York Edison Co. held Feb. 16, Charles E. Mitchell, chairman of the board of the National City Bank, and George Whitney, member of the firm of J. P. Morgan & Co., were added to the executive committee. R. H. Tapscott, electrical engineer of The New York Edison Co., and Arthur H. Kehoe, electrical engineer of the United Electric Light and Power Co., who were elected vice-presidents of the United company, were made vice-presidents of the New York Edison also.

LUNKENHEIMER CO., Cincinnati, Ohio, announces with profound sorrow the death of Lane Thompson on Sunday, February 7, 1932.

CENTRIFIX CORP., Cleveland, Ohio, announces the appointment of the following representatives: J. A. Dougherty, who who will handle the territory of northern Ohio from the home office at Cleveland; Chas. M. Swart, who will handle the state of North Carolina from Greensboro; Messrs. Green & Boulding, Ltd., 162a Dalston Lane, London, who will handle the account in Great Britain and Ireland; W. A. Ramsey, Ltd., Fort & Queen Sts., Honolulu, who will represent the company in Hawaii.

FORT WORTH offices of the International-Stacey Corp. and those of its subsidiary companies, International Derrick & Equipment Co., Roots-Connersville-Wilbraham, Stacey Brothers Gas Construction Co. and Stacey Manufacturing Co. have been moved to room 307, Southland Life Insurance Co., Dallas, Texas. F. W. Mohler, midcontinent sales manager and C. B. Coldwell, sales engineer for the Stacey and Roots-Connersville-Wilbraham divisions and S. B. Creamer, sales engineer, will be located in the Dallas office.

ARRANGEMENTS are being made by Midwestern Engineering Exposition, Inc., for the 6th Chicago Power Show to be held in the Coliseum, June 25-30, 1933, during the first month of the Chicago World's Fair. Meetings of engineering societies will be held during the same week. Reservations are now being filed in the order of receipt; full information being obtainable from G. E. Pfisterer, managing director, 308 W. Washington St., Chicago, Ill.

ALCO PRODUCTS, Inc., has received orders for 1000 tons of riveted steel tunnel lining to be used in the 20-mi. aqueduct, known as City Tunnel No. 2, under construction between Yonkers and Brooklyn, New York. The lining is one inch thick, from 15 to 20 ft. in diameter and weighs approximately 2 t. per ft.

ANNOUNCEMENT is made of the appointment of Pacific Pipe & Supply Co., Los Angeles, as jobbers of Tube-Turns.

For the Engineer's Library

PREPARATION AND ADMINISTRATION OF BUDGETS—Suggested Methods for Electric Light and Power Companies, has just been issued by the N.E.L.A. Publication No. 23 by the Budget Committee Accounting National Section, National Electric Light Association, New York City. It incorporates a complete discussion of methods for preparing and administering budget systems for electric light and power companies based on 10 yr. actual experience of the industry.

Importance of a sympathetic and constructive management attitude toward budgetary operation is stressed as being the greatest single factor contributing to a successful forecast of activities and control of expenditures. Need for proper organization is emphasized so that administrative policies will be readily accepted and the responsibility for attaining results clearly and correctly placed. Forms and methods used by member companies are presented for the information of those who are interested in the technique of budget procedure.

NOISE AND VIBRATION ENGINEERING, by Stephen E. Slocum; cloth, 6½ by 9 in.; 167 pages, 74 illustrations; D. Van Nostrand Co., Inc., 250 Fourth Ave., New York; price $2.75.

In view of the recent development of a widespread public opinion to the effect that engineers and civil servants should be called upon to combat the evils arising from unnecessary noises and vibration, this book should prove helpful to all engineers. It is a pioneer work on the subject of vibration and its various aspects in engineering, commercial, industrial and civic fields. One of its principal virtues is that the text may be read for general information on the subject without going too deeply into the mathematical solution of specific problems although the mathematical treatment is there if one needs it and the final chapter gives in much detail the mathematical groundwork of the subject.

General subjects treated are: transmission of elastic ground waves, properties of vibration dampers and insulators, vibration insulation of tall buildings, vibration due to street traffic, subway noise and vibration, machinery insulation, sound deadening and acoustic correction, economic aspect of noise abatement. A comprehensive bibliography and an index are provided.

PHILGAS CO., General Motors Building, Detroit, Mich., is distributing a new bulletin, No. 34, describing the practical applications of G-4 Butane gas, with particular reference to its application at the Pressed Steel Tank Co. of Milwaukee, who recently changed from city gas to butane.

G. E. ELECTRIC STEAM GENERATORS is the title of Booklet GEA-1372-A superseding GEA-1372 recently issued by the General Electric Co. It describes various applications of electric steam generators in industry. Among other new bulletins issued by the General Electric Co. are GEA-1521 on low temperature fuse links for distribution cutouts, and GEA-1262-B superseding GEA-1262-A showing applications of G. E. Thrustors. Bulletin GEA-1123-A supersedes GEA-1123 on outdoor switching equipment.

MEASURING WATER in Irrigation Channels is the subject of Farmers' Bulletin No. 1683, recently issued by the U. S. Department of Agriculture, Washington, D. C. It consists of a discussion by R. L. Parshall of weirs, Parshall measuring flume, velocity of approach and loss of head. While the purpose of the bulletin is to encourage and assist in the use of more accurate methods of measuring water flow in open irrigation channels, the methods of measurement described may prove of interest and value to power plant engineers, as undoubtedly some of these methods could be used in various kinds of testing work, both in central stations and industrial plants. Complete directions and tables of dimensions are given for various types of weirs that can be built of simple materials, together with a rather complete discussion of the principles involved and the methods of applying them.

BULLETIN H-7 devoted to Elliott steam turbine-generators, setting forth design and construction details of the latest type units, with large sectional view and detail pictures has just been issued by Elliott Co., Jeannette, Pa. There is a section on Turbine Efficiency with a total heat-entropy diagram and chart of overall efficiencies. Numerous installation pictures are presented. Bulletin J-4 describes Elliott commutating-pole direct-current motors and generators and describes these machines with particular comment on armature windings, double-section commutator construction, and the like.